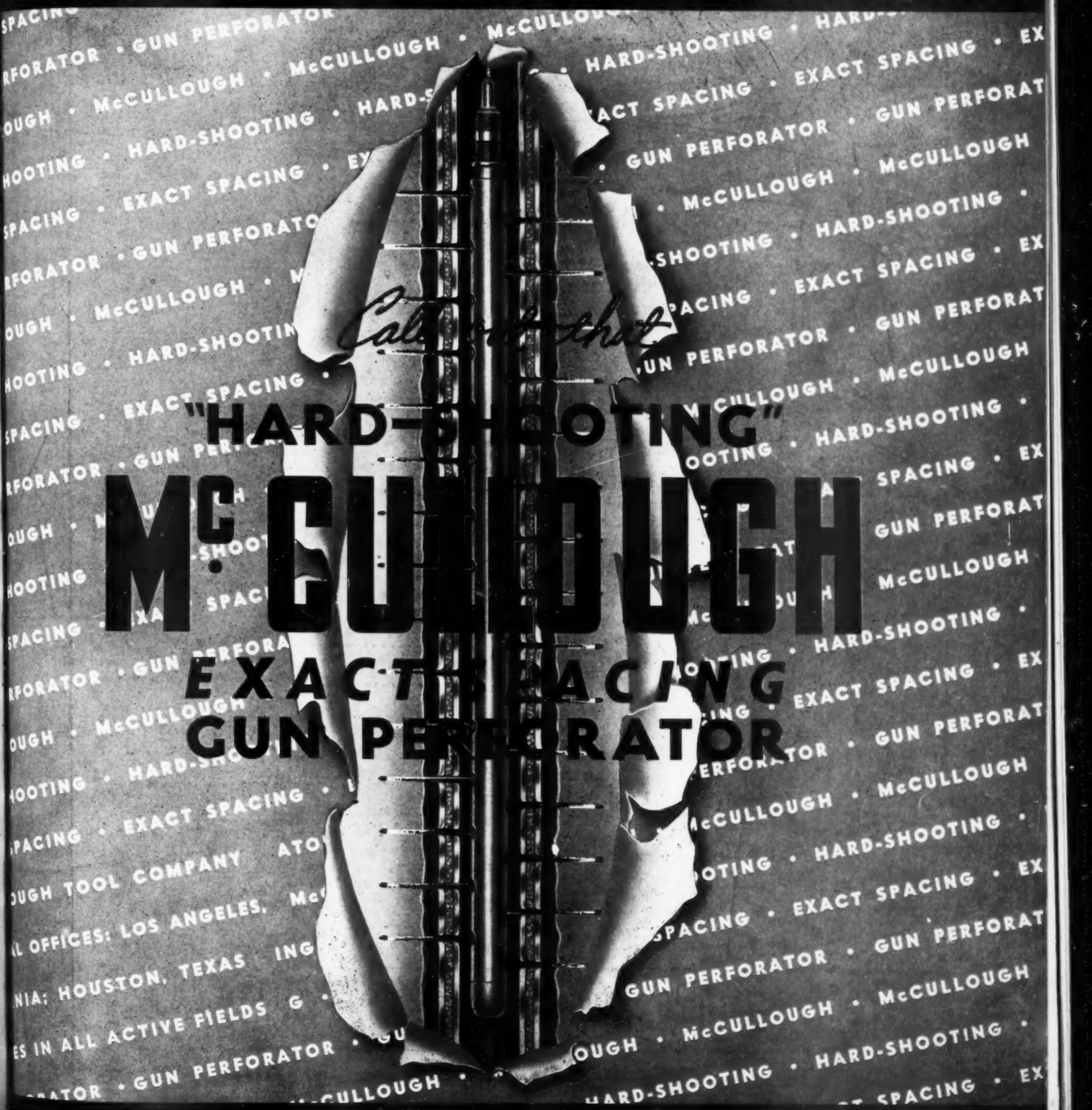
DRILLING
AND PRODUCTION

PIPE LINE

REFINING
NATURAL GASOLINE



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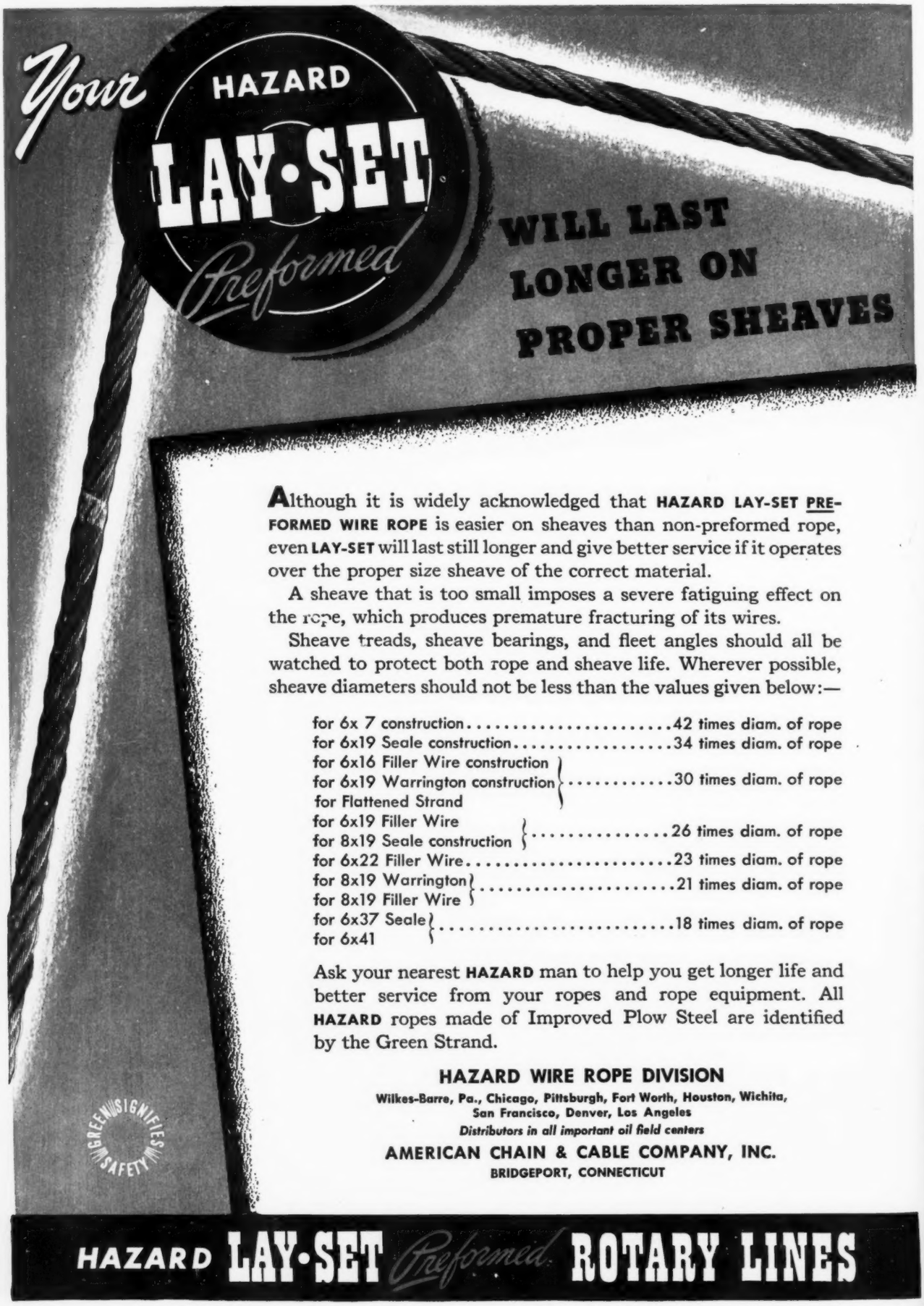
SERVICES IN ALL ACTIVE FIELDS



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for 6x19 Seale construction	34 times diam. of rope
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for 6x22 Filler Wire	23 times diam. of rope
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for 6x37 Seale for 6x41	18 times diam. of rope

Ask your nearest **HAZARD** man to help you get longer life and better service from your ropes and rope equipment. All **HAZARD** ropes made of Improved Plow Steel are identified by the Green Strand.

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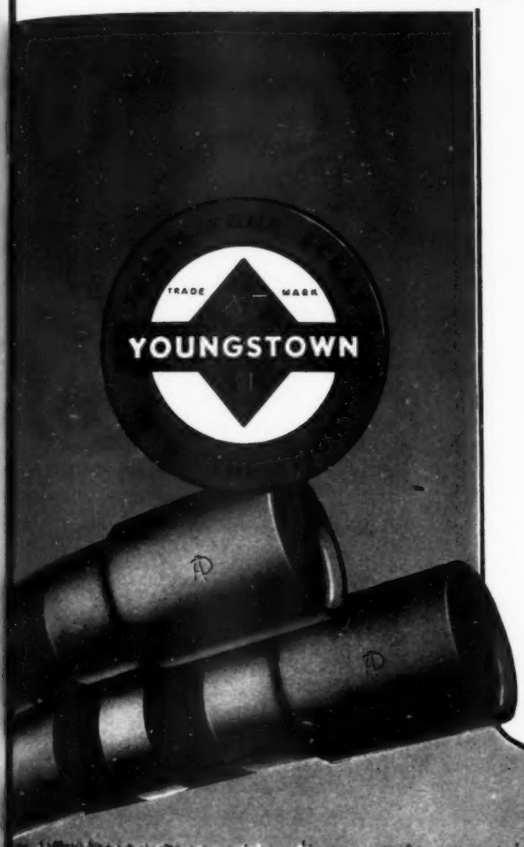

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YOUNGSTOWN, OHIO

March, 1943

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MEMBER A. B. C.—A. B. P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N.

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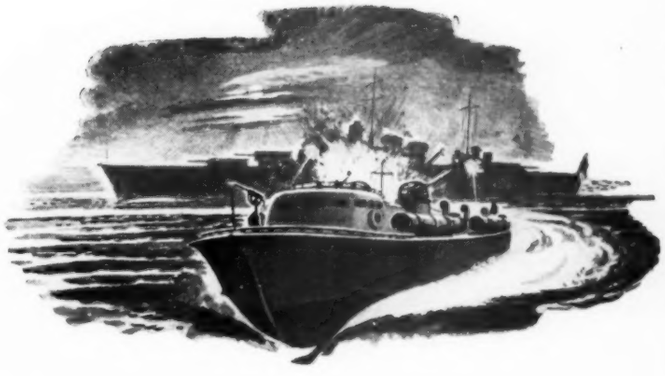
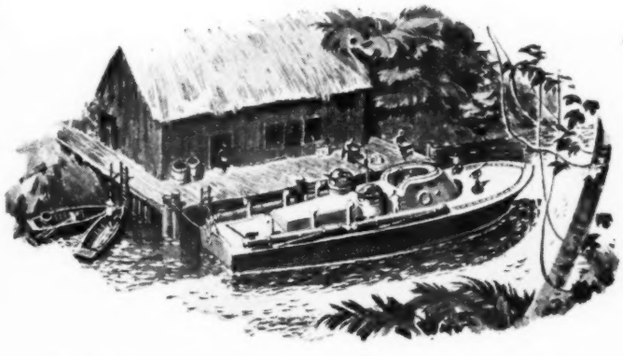
Once more it's Wooden Ships and Iron Men!

As in the days of John Paul Jones, the Navy's newest arm is composed of wooden ships . . . and iron men. Powered with Packard engines (many equipped with American Hammered Piston Rings), the PT's travel like a terrified hurricane, and speed and spirit are their only armor. December 7 found a fleet of six in the Philippines.



These PT's wrote a glowing page in naval history. Trading punches and giving odds, their score was one Jap cruiser, one 5000 ton (aircraft?) tender, one 5000 ton ship, and 2 landing barges sunk; 2 cruisers damaged, a tanker fired, and 3 dive bombers and one seaplane destroyed. Reefs damaged more PT's than shell fire.



Schedules called for replacement of engines after a few hundred hours, because of the terrific beating they took . . . but bombs had blasted the spares. Repair facilities were primitive. Yet some of these old engines were still serving after 4 times normal life. What a test for the rings! . . . a test they passed with flying colors.

This capacity for service above and beyond line of duty comes from 25 years of foundry, shop, inspection and engineering experience in solving tough ring problems. Where the last ounce of effort is essential, you'll generally find these rings on the job. Koppers Company, American Hammered Piston Ring Div., Baltimore, Md.

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KOPPERS

THE INDUSTRY THAT SERVES ALL INDUSTRY

The Course of Oil

by K. C. SCLATER

WAR PIPE LINES

Under the pressure of war the demands made on the pipe line transportation branch of the petroleum industry are without precedent. The loss of tankers carrying oil from the Gulf Coast and from Venezuela to the Atlantic Seaboard created serious petroleum shortages that had to be met. So critical were these shortages that it resulted in the decision to construct the so-called "Big Inch" line from East Texas to refineries in the East. Despite unavoidable delays and almost insuperable problems, the first half of this line from East Texas to Norris City, Illinois, has just been put into operation less than seven months after the line was started. The story of its construction and the difficulties overcome are an achievement of which the petroleum industry—especially the pipe line branch—has reason to be proud.

Besides the "Big-Inch" line, which, because of its magnitude, has attracted more national attention than other projects, many other significant changes in pipe line facilities have been and are being made. The taking-up and relaying of miles of existing pipe lines, reversing the direction of flow in others, are all part of the transformation necessitated by the exigencies of war.

War has stressed the importance of the nation's network of petroleum pipe line transportation systems. Little was it realized that the capacity of the industry to produce its full quota of petroleum to meet war needs would be curtailed because of lack of transportation facilities. There are some fields that could produce more oil were pipe line and adequate storage facilities available. Completion of the "Big-Inch" line and necessary tankage will aid in relieving this condition. Our greatest transportation problem, however, has not been in this connection; it has been caused by the loss of tankers. Up to now shortages have been met, though at high cost, by pressing into service all available railroad tank car transportation, but urgent need for greater petroleum supplies has emphasized the necessity to rush completion of the last leg of the "Big-Inch" line. Some of the engineering and practical phases of what this vast undertaking has involved are disclosed in several articles in this issue.

Besides the "Big-Inch" line, a new 20-inch petroleum products pipe line will be constructed from the Houston-Beaumont refining areas of Texas to Indiana, further evidence of the urgent need for pipe line facilities. In addition, Petroleum Administrator Ickes has said that in the light of current developments, particularly in the military sphere, and the future prospects so far as any of us can anticipate the future, it is his judgment that the 20-inch petroleum products line must be completed through to the Eastern Seaboard. The eastern leg of this line still has to be approved by the War Production Board.

DISPOSITION AFTER EMERGENCY

What to do with these pipe lines after the war, has already had the attention of the Petroleum Industry War Council, which passed a resolution calling upon the Petroleum Administration or any successor agency to call the industry into conference after the tanker emergency is passed, or at any event six months after the end of the war, to determine the disposition and future use of all oil pipe lines built with government funds. That the Petroleum Industry War Council recognizes, even now, the need for determining the disposition and future use of government pipe lines when the war emergency has passed, is evidence of the industry's concern regarding government participation in pipe line facilities after the war.

RUBBER PROGRAM REPORT

From a close reading of Progress Report No. 2 of Rubber Director Jeffers, one gets a good idea of the difficulties faced in outlining a definite program and adhering to it under war conditions. War requirements are not always predictable, for the fortunes of battle may undergo vast changes overnight. Add to that the unpredictables in pioneering a new process and you begin to realize the complications that confront the rubber program.

As has been pointed out in Director Jeffers' report, new developments have necessitated changes. For example, it has been found that the shortage of critical items of machinery are so great that the conversion of refineries for "quick" butadiene production cannot be completed in the time originally envisioned by the Baruch Committee. It has also been decided that there are other programs of equal urgency with that of rubber, thus necessitating further delay in completing the rubber program. It has also been found out that the urgent need for high-octane gasoline makes it essential that everything possible be done to avoid unnecessary drains upon components, facilities, feed stocks, and labor usable by both the rubber program and the high-octane gasoline program. Still another factor is that some of the large butadiene manufacturing units may ultimately run at more than their original rated capacity.

It has therefore seemed advisable to cancel some of the more recently approved refinery conversions that could not be expected to contribute much, if any, "quick" butadiene needed during the summer and early fall of this year.

Imponderables in the synthetic rubber program are many. Failure to recognize this fact leads to unjust criticism, which in turn confuses the public.

—Official U. S. Navy Photograph

In fulfilling its destiny, steel wire rope is now called upon to withstand the wear, tear, stress and strain of war time production. Its fields of service are the "hot spots" of industry. Shipyards, oil fields, mines, mills, steel plants . . . are a few of its important battle stations.

While wire rope is designed for hard work, its actual life span is definitely influenced by the way in which it is handled, as well as by the condition of the equipment on which it is used. Kinks, reverse bends, corrugated sheaves, improper fleet angle, incorrect or insufficient lubrication—are some of the adverse factors that are often encountered.

As so much steel is required to provide the sinews of war, it is obvious that the more hours of work that can be had from every pound of wire rope used, the more steel — and time — will be saved. Let us make every saving possible of these two vital items, so that our fighting forces will have plenty to fight with, *and when needed.*

For further information on the proper use, care and application of wire rope, as well as regarding any wire rope problem that you have . . . feel free to consult our Engineering Department.

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Highlights IN OILDOM

A.P.I. Reports on New Petroleum Reserves

The petroleum industry found 1,878,976,000 bbl. of new oil during 1942, or 493,497,000 bbl. more than the 1,385,479,000 bbl. of crude oil produced during the year, the American Petroleum Institute's Committee on Petroleum Reserves has announced.

The net increase raised total known underground reserves of petroleum as of December 31, 1942, to 20,082,793,000 bbl. Total reserves on January 1, 1942, (December 31, 1941) were 19,589,296,000 bbl. These estimates include only the reserves known or blocked out in proved fields, and recoverable by present production methods.

Most of the new oil was added through upward revisions of reserves in fields found prior to 1942, however. Further development of these older fields revealed a net addition of 1,618,925,000 bbl. of crude oil that had not been included in previous estimates for those fields but which is now indicated by additional development information.

The committee stressed the fact that its estimates of reserves do not reflect the availability or the rate at which these reserves can be produced. "For instance," the committee stated, "arbitrary division of the known reserves by a current rate of production or by any anticipated rate of consumption is obviously incorrect" and that "as a matter of fact, today's known oil can be recovered only over a period of many years and at gradually declining rates, as has been widely demonstrated by past performance under all kinds of operating conditions."

The Institute committee signing the report included: J. Edgar Pew, chairman, Sun Oil Company, Philadelphia, Pennsylvania; R. F. Baker, The Texas Company, New York, New York; D. V. Carter, Magnolia Petroleum Company, Dallas, Texas; Frank R. Clark, The Ohio Oil Company, Tulsa, Oklahoma; Alexander Deussen, consulting geologist, Houston, Texas; G. Clark Gester, Standard Oil Company of California, San Francisco, California; F. H. Lahee, Sun Oil Company, Dallas; J. M. Sands, Phillips Petroleum Company, Bartlesville, Oklahoma; Fred Van Covern, American Petroleum Institute, New York; Theron Wasson, The Pure Oil Company, Chicago, Illinois, and Fred E. Wood, Standard Oil Company (Indiana), Chicago.

Texas Stripper Well Abandonments Excessive

Excessive taxation on Texas oil is dealing a death-blow to thousands of stripper oil wells in this State, according to George Sawtelle, president of the Texas Mid-Continent Oil and Gas Association.

As a direct result of constantly increasing taxes and higher operating costs against crude oil, Sawtelle said that in 1941 and 1942 Texas oil operators were forced to abandon nearly three times as many wells as were abandoned in six preceding years. He cited the fact that during the last two years the number of stripper oil wells abandoned averaged 3395, against an annual average of 1355 wells abandoned in the previous six-year period 1935-40.

Premature abandonment of stripper wells in the last two years, he added, resulted in the loss of 33,000,000 bbl. of recoverable oil a year, against an average of 13,000,000 bbl. a year lost by abandonments in six preceding years. A recent survey of stripper wells in Texas, according to Sawtelle, showed that every well prematurely abandoned leaves about 10,000 bbl. of otherwise recoverable oil in the ground. Yet, when high costs, including excessive taxes, result in a loss on such operations, the oil producer is forced to abandon the wells and recover the salvage value of his equipment.

Sawtelle stated that taxes levied against Texas crude oil have been increased 3 cents per bbl. since 1940, making the average tax cost per barrel of oil now being produced 12 cents. At present market prices for crude oil this tax amounts to more than 11 percent of the oil producer's gross income after deducting the customary one-eighth royalty owner's interest.

A study of stripper well operations in Texas, which was sponsored by the Interstate Oil Compact Commission, showed that the average net profit on such operations is only 4 cents per bbl. "Even a small increase in taxes," Sawtelle said, "can end the productive life of such properties and not only result in the loss of needed oil but also the loss of employment and taxable values to the State and the local communities."

"In the face of these facts," Sawtelle concluded, "efforts are being made to further increase the taxes of the Texas oil industry, which would in effect add another 7 cents a bbl. against crude oil production. There are over 30,000 stripper wells in Texas today and the oil they produce, and that which may yet be recovered from underground reserves, is vital to the nation's war requirements. To force the further abandonment of oil wells now, when the nation needs every barrel which can be found and produced, is decidedly detrimental to the war effort and contrary to sound economic principles."

"Travel Expense" May Be Considered Wages

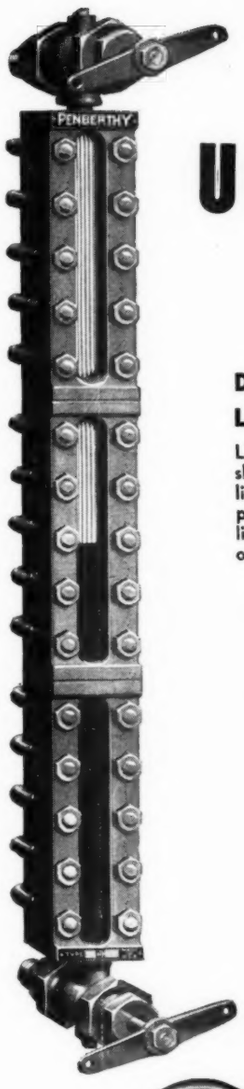
Drilling contractors who are paying a special travel expense or travel allowance to crewmen may be required to regard such extra compensation as "wages," according to a revised opinion of the Dallas office of the Department of Labor. The latest opinion was in answer to a question from the American Association of Oilwell Drilling Contractors concerning the status of an employer paying various types of "travel expenses." The question asked the Department of Labor was:

"Where a drilling contractor voluntarily pays an employee $1.00 per day for travel expense or 'travel allowance,' as a means of repaying said employee for use of his car, or for covering the approximate cost of going to and from the job in any other manner, is such payment in conflict with provisions of either the Wage and Hour Act or Executive Order 9250?"

The reply follows:

"On January 8, I wrote you in reply to an inquiry made by you under date of January 5. You had asked whether allowance of $1.00 a day to employees of drilling contractors as travel allowance would become part of the wage of the employee, upon which overtime should be paid under the Fair Labor Standards Act. In my letter, I stated that in my opinion such a plan would not be 'wages,' but that I desired to present the question to the central office in New York.

"I am in receipt of a reply to the inquiry made of the Administrator's office, in which the opinion is expressed that such a payment would probably be considered 'wages.' It was pointed out that the assumption of travel expense by the employer might be regarded as a wage increase and considered as such under the Wage Stabilization Order (Executive Order No. 9250); or that it might be considered 'hours worked.' The facts I was able to furnish in connection with my inquiry were not considered sufficient for a definite determination to be made. But, as I have stated above, they were inclined to think that such a cash payment to cover cost of transportation could very readily be considered a part of the wages and, therefore, to be taken into account in determining the basic rate of pay upon which overtime should be calculated."



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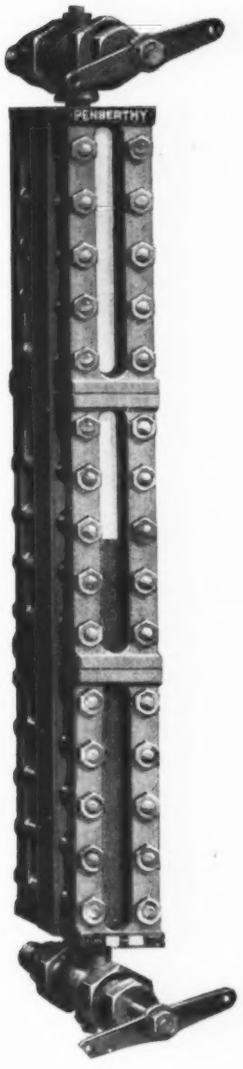

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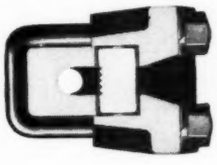
DROP FORGED STEEL LIQUID LEVEL GAGES

Liquid shows black—empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.



PENBERTHY
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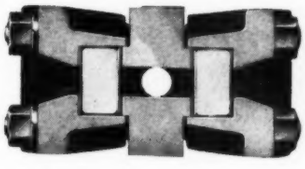
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . similar to Reflex types.



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Water shows black—steam shows white. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

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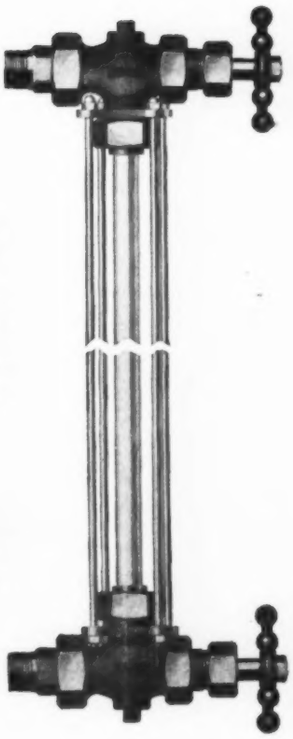

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PENBERTHY PRODUCTS

MAJOR *Pipe Line* ACTIVITIES

THE Great Lakes Pipe Line Company has purchased 60 miles of 6-in. pipe line built by the Tide Water Associated Oil Company, Deep Rock Oil Corporation, Cushing Refining and Gasoline Company, and Johnson Oil Refining Company for moving products from their refineries at Cushing, Drumright, and Cleveland, Oklahoma, to the Great Lakes trunk line. Four small pump stations, one at each refinery, were also included in the purchase.

Work of removing booster-station equipment and reinstalling it at other locations on the Great Lakes system will be completed in March. Electric-centrifugal pumping equipment has been moved from idle stations to increase capacity of the system at points northeast of Kansas City, Missouri.

Right-of-way work for a new gas pipe line from the Guymon area, Oklahoma, to near Hugoton, Kansas, in the Hugoton gas field has begun with C. F. Seagraves, Republic Natural Gas Company, directing the work. Survey for the line is being completed by W. B. Crawford, engineer of Hugoton.

The line to be constructed of 16-in. pipe, 18 miles in length, will connect the Ferguson, Ebersole, and Hempsten leases, southwest of Guymon, extending north to three miles east of Hugoton, to connect with a trunk system.

The Defense Plant Corporation is purchasing at a cost of about $2,625,000 a natural gas transmission pipe line of the Houston Gulf Gas Company. The line extends 145 miles from Refugio to Pierce Junction, Texas, and will be used to connect oil pipe lines between Corpus Christi and Longview, Texas. Purchase was made on recommendation of the Petroleum Administrator for War, Harold Ickes. It will supply Gulf Coast refiners deprived of sweet East Texas crude oil by the construction of the 24-in. pipe line from Longview to Norris City, Illinois.

The trans-Florida pipe line is now completed and in operation transporting gasoline from Carabelle, on the Gulf Coast, to Jacksonville, on the Atlantic Coast. Total length of the 8-in. line is 199 miles.

Materials for construction of the line were second-hand. Pipe, pumps, and storage tanks were taken from the American Liberty Pipe Line Company's system in Texas. Financed by the Defense Plant Corporation at a cost of approximately $3,360,000, the line is operated by the Trans-Florida Pipe Line Company. Its capacity is about 30,000 bbl. of product per day.

Although gasoline is being transported at present, other petroleum products will be moved later to be transshipped from Jacksonville by the intracoastal waterway to consuming centers along the coasts of Florida, Georgia, and the Carolinas.

Natural gas from the Panhandle in Texas will supplement Ohio and West Virginia wells in supplying heavy wartime demand in the Cleveland-Akron-Youngstown industrial area, if plans made by the East Ohio Gas Company and the Panhandle Eastern Pipe Line Company are approved by the War Production Board.

Through an agreement reached by the companies, East Ohio will construct a 20-in. pipe line from its Brush Farm valve station midway between Cleveland and Akron westward to Maumee, Ohio, where it will tap Panhandle's 24-in. line running to Detroit. Deliveries will be up to 50,000,000 cu. ft. a day and will approximate 30 percent of East Ohio's present daily average sales. East Ohio has call on another 50,000,000 cu. ft. a day, contingent on Panhandle being able to deliver. Construction costing $3,250,000 will include East Ohio's 120-mile line and filling in of gaps now existing in the second pipe of Panhandle's dual 24-in. line.

Permission to acquire all assets of its two subsidiaries, Illinois Natural Gas Company and Michigan Gas Transmission Corporation and to return for cancellation and retirement all securities held by the parent company in the two concerns, thereby dissolving Illinois and Michigan, has been requested by The Panhandle Eastern Pipe Line Company from the Securities and Exchange Commission.

As Panhandle owns all outstanding capital stock in the two subsidiaries, under the proposed plan all properties, assets, and liabilities of the subsidiaries will be assumed by the parent company. According to the application, the transaction will simplify accounting and operating routine through ownership by Panhandle of all natural gas transmission facilities and will save more than $100,000 per year.

Formal application to the War Production Board for the allocation of materials necessary for construction of an extension to New York and Philadelphia of the 20-in. steel pipe line for gasoline shipments already approved from Beaumont, Texas, via Norris City, Illinois, to Seymour, Indiana, and for construction of terminal facilities at these two East Coast Cities, has been made by Petroleum Administrator for War Harold L. Ickes.

The first segment of the gasoline line, 836 miles in length, from Beaumont to Seymour, will be under construction as quickly as possible. Ickes stated that if permission for the East Coast extension is granted by WPB, the line should be ready for operation before the end of the year. It is estimated that the Texas-Indiana section can be completed by September.

This second "Big Inch" line is expected to transport 235,000 bbl. of refined petroleum products per day, principally gasoline and fuel oil.

A letter from Ickes to Donald M. Nelson detailed the need for completion of the proposed extension of the line to the East Coast.

"In the light of current developments, particularly in the military sphere," Ickes wrote, "and the future prospects so far as any of us can anticipate the future, it is my judgment that the 20-in. petroleum products pipe line from Texas, the first installment of which to Norris City, Illinois, and Seymour, Indiana, has already received the approval of the War Production Board, must be completed through to the eastern seaboard."

"Orders have been placed for all pipe needed for construction of the first leg of the 20-in. line," Ralph K. Davies, Deputy Petroleum Administrator, said. "Negotiations for motors, pumps, valves, transformers, and supplemental equipment and materials will be concluded within the next few days. Construction crews will assemble shortly and actual construction should be underway before the end of this month."

Transportation officials of the Petroleum Administration said the proposed extension of the line from Seymour to the East Coast, if approved by the WPB and materials are made available, will be built along the same route as that of the 24-in. line. The new line will be laid on the same right-of-way, thus eliminating the necessity for obtaining new ground on which to lay the line.

facts

concerning replacement parts for

DE LA VERGNE DIESEL ENGINES

America's war production has created unprecedented demands for De La Vergne diesel engines. Our shops are working 24 hours a day, producing De La Vergne diesels to aid our armed forces to bring Victory at the earliest possible moment. Naturally, new diesel engines must come first. But in spite of this, we are doing everything in our power to produce replacement parts despite the difficulty in securing critical and other materials.

You can aid the war effort, yourself, other owners and us here at Baldwin by ordering only those replacement parts you need to keep your De La Vergne in operation. We will do our best to get you what you need, as quickly as we are permitted to make and ship parts.

Your cooperation and patience will be sincerely appreciated, by us, our many customers and those units of the armed forces which are using De La Vergne to speed Victory. Baldwin De La Vergne Sales Corp., a subsidiary of The Baldwin Locomotive Works, Philadelphia, Pa.

MAJOR *Oil Field* ACTIVITIES

MICHIGAN has a new oil pool discovered by the Ohio Oil Company. Zimmerman No. 1, 28-18n-9w, Osceola County, is being produced from the Dundee sand at a depth of 3832 ft. at the rate of 30 bbl. per hour on a five-hour test.

The Wolf Creek Oil Company has found a new producing area in Kansas four miles west of the Eldorado Pool. The well, Allen No. 1, 2-26-3e, pumped 15 bbl. of oil without a show of water in 24 hours from the Mississippi lime at a plugged-back depth of 2720 ft. The well was treated with 5000 gal. of acid. Casing, 7⅝-in. diameter, was landed at 2675 ft.

David No. 1 is the discovery well of the latest pool opened in Runnels County, Texas, two and one-half miles southeast of Winters, Texas. The well was completed at a plugged-back depth of 2495 ft. and is pumping 91.14 bbl. of estimated 45-gravity oil and 140.5 bbl. of sulphur water through 2-in. tubing per 24 hours.

The well had been gun-perforated from 2464-66 ft. with 10 shots. Production of the well will go to Moutray Oil Company at Abilene, Texas. Elevation of the well, owned by Pawnee Royalty Company, was 1786 ft. and topped the Ellenburger at 4570 ft.

The Sun Oil Company's Burleigh No. 1, section 37-7s-4e, at Shuteson, St. Landry Parish, Louisiana, started potential gauge after separator and storage were installed. The well came in to flow between 3 and 5 bbl. of 31-gravity oil per hour through a 9/64-in. choke from perforations at 9495 to 9505 ft. Tubing pressure was 900 lb. and casing pressure 250 lb. Total depth of the well is 11,505 ft. with 7-in. casing landed at 10,735 ft.

Completion of the only discovery well of the year at Napoleonville in Assumption Parish, Louisiana, by George Echols and Tide Water Associated Oil Company, Kessler and Sternfels No. 1 on the east flank of the Napoleonville dome, section 136-12s-14e, produced 192 bbl. of 37.5-gravity oil per day through ⅛-in. choke from perforations at 9034-38 ft. with 1250-lb. tubing pressure. Eighteen feet of saturated sand were found in the wildcat from 9031-49 ft. in the Miocene. Total well depth is 9170 ft.

Cities Service Oil Company is preparing to officially gauge its Wilcox sand discovery in the Ramsey area of Colorado County, Texas, Frank Stephens No. 1. The well was perforated from 8948-70 ft. to flow an estimated 148 bbl. of distillate and about 4,000,000 cu. ft. of gas per day through ¼-in. choke. About 100 bbl. of distillate and some 3,400,000 cu. ft. of gas were produced from perforations at 8320-40 ft. in the Wilcox sand. The discovery is on a 489-acre tract, P. K. Bartlesson survey, abstract 84, north of Eagle Lake and 10 miles northeast of Columbus. Total well depth is 10,505 ft. with 5½-in. casing set to 10,504 ft.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.23-1.29
Playa Del Rey	.80- .87
Coalinga	.73-1.13
Wilmington	.68-1.24
Montana	1.00-1.15
Wyoming	.45-1.15
Colorado	1.05-1.07
New Mexico	.70-1.15
Texas	
North Central	.97-1.21
Panhandle	.70-1.12
West Texas	.80-1.27
Gulf Coast	.93-1.48
Darst Creek	1.14
East Texas	.80-1.27
Talco	.79
Kansas	.93-1.25
Oklahoma	.75-1.25
Arkansas	.94-1.36
Louisiana	
Rodessa	$ .88-1.20
Gulf Coast	.93-1.36
North Louisiana	.98-1.30
Illinois	1.22-1.37
Kentucky	1.32-1.43
Indiana	.85-1.25
Ohio	
Lima	1.50-1.60
Michigan	1.24-1.44
Pennsylvania	
Bradford	3.00
Southwest	2.65
Eureka	2.59
Buckeye	2.30
Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.
(Figures in bbl. of 42 gal. each)

	[1]P.A.W. Recommendations February	Week Ended Feb. 27, 1943	Week Ended Jan. 30, 1943	Week Ended Feb. 28, 1942
Oklahoma	395,300	[2]350,450	374,750	393,700
Kansas	310,500	[2]306,400	291,800	230,000
Nebraska	3,000	[2] 2,550	2,350	4,450
Panhandle Texas		88,900	88,400	86,700
North Texas		135,350	136,700	148,700
West Texas		213,900	201,100	300,650
East Central Texas		102,250	101,600	91,400
East Texas		325,100	327,600	368,400
Southwest Texas		166,350	166,700	222,700
Coastal Texas		319,600	308,800	296,700
TOTAL TEXAS	1,452,000	1,351,450	1,330,900	1,515,450
North Louisiana		89,750	91,850	81,500
Coastal Louisiana		246,550	247,700	270,600
TOTAL LA.	349,800	336,300	339,550	352,100
Arkansas	78,700	75,150	74,900	73,850
Mississippi	50,000	[2] 53,300	55,300	90,850
Illinois	272,200	228,500	229,550	334,900
Indiana	17,200	[2] 14,100	16,600	19,150
Eastern (Not incl. Ill. & Ind.)	114,600	100,500	94,500	95,550
Michigan	63,700	57,500	60,800	50,850
Wyoming	94,100	90,550	89,950	84,400
Montana	24,700	21,950	22,300	21,600
Colorado	7,000	6,550	6,350	5,550
New Mexico	105,800	96,600	98,300	120,400
TOTAL EAST OF CALIF.	3,338,600	3,091,850	3,060,900	3,392,800
California	823,700	781,200	765,500	622,850
TOTAL U. S.	4,162,300	3,873,050	3,826,400	4,015,650

[1]P.A.W. recommendations and state allowables represent the production of all petroleum liquids, including crude oil, condensate and natural gas derivaties recovered from oil, condensate and gas fields. Past records of production indicate, however, that certain wells may be incapable of producing the allowables granted, or may be limited by pipeline proration. Actual state production would, under such conditions, prove to be less than the allowables. The Bureau of Mines reported the daily average production of natural gasoline and allied products in November, 1942, as follows: Oklahoma, 29,900; Kansas, 5,800; Texas, 106,300; Louisiana, 20,800; Arkansas, 3,000; Illinois, 10,300; Eastern (not including Illinois and Indiana), 11,500; Michigan, 100; Wyoming, 2,600; Montana, 300; New Mexico, 5,800; California, 42,100.

[2]Oklahoma, Kansas, Nebraska, Mississippi, Indiana figures are for week ended 7 a. m., February 24.

gets maximum *Production* from *All* the pay

The urgent and expanding demand for petroleum makes it imperative that maximum production be secured from all parts of every pay zone. The necessity of meeting these requirements with minimum amounts of materials, manpower and time makes Dowell Selective Acidizing an indispensable part of every well-planned workover and completion program.

Selective Acidizing utilizes the various tools, techniques and materials that have been perfected by Dowell engineers during more than a decade of pioneering work in the chemical treatment of wells. One of the latest and most important additions to this list of specialized equipment is the Dowell Electric Pilot. It is used to direct the acid into certain selected portions of the formations and to eliminate the possibility of treating the undesirable sections.

Information concerning the many applications for Selective Acidizing can be obtained from the Dowell Representative in your area or by writing Dowell's Tulsa Office.

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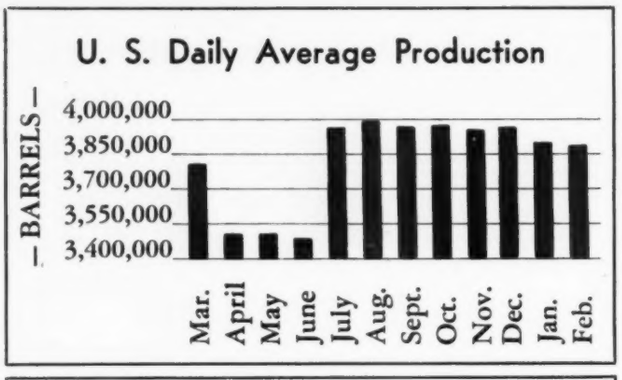
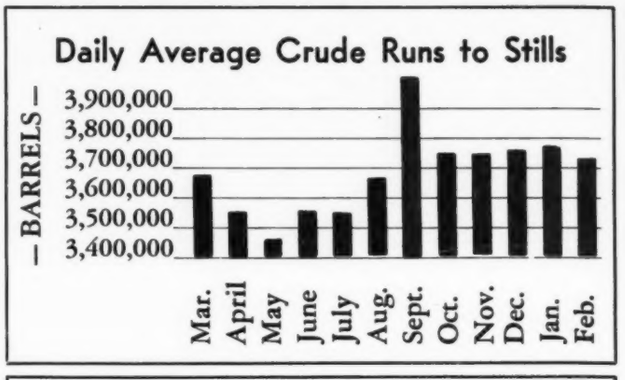
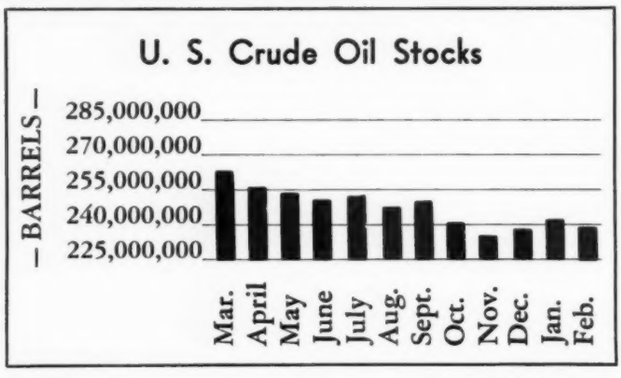
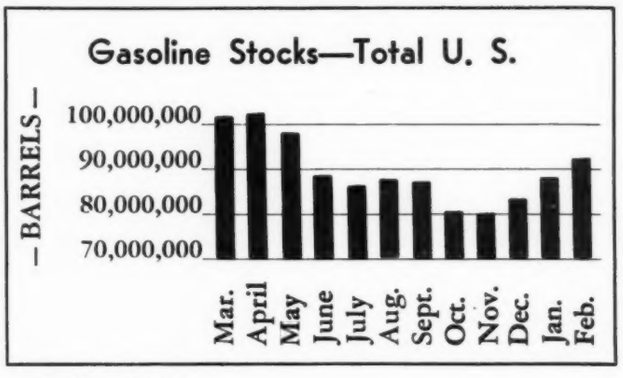
FOR OIL AND GAS WELL CHEMICAL SERVICE

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for February, 1943

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	34	29	3	....	3500-3700	2	40	Rotary
Gaines County	3	2	5	....	4400-5584	2	22-35	Rotary
Hockley County	6	4	3	....	4800-6850	2	20-30	Rotary
Ector County	3	2	5	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	25	18	4	....	1700-3900	2	40	Rot.-Cab
Nueces County	5	4	6	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	5	3	4	....	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	10	9	5	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	4	2	7	3	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	9	6	6	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	6	4	5	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	7	5	2	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	159	140	72	129	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	14	11	5	2	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	2	1	4	1	1840-11,450	3 or 4	14-30	Rotary
Wilmington Field	3	1	3	1	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for February, 1943

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1942 (In Barrels)
	February	January	February	January	February	January	February	January	February	January	
Arkansas	12	8	8	6	8	14	3	3	7	15	26,560,000
California	62	81	46	77	16	21	21	33	26	38	248,250,000
Illinois	159	168	140	147	39	46	72	68	129	140	105,768,000
Indiana	23	20	20	18	22	11	4	4	8	6	6,680,000
Kansas	135	124	114	118	58	53	15	13	21	17	90,920,000
Kentucky	9	11	3	7	2	7	....	....	....	....	4,503,000
Louisiana	176	171	161	153	61	39	18	11	19	14	125,450,000
Michigan	24	27	19	19	8	5	11	9	6	3	21,568,000
Mississippi	4	3	2	1	....	....	....	....	....	....	27,605,000
Montana	8	10	6	8	....	....	....	....	....	....	8,998,000
Nebraska	2	2	1	1	3	2	....	....	....	....	1,367,000
New Mexico	32	29	29	26	25	20	....	....	....	....	31,875,000
New York	76*	84*	66*	68*	53	47	....	....	....	....	5,132,000
Ohio	51	61	44	45	38	36	....	....	....	....	3,480,000
Oklahoma	132	125	125	120	21	14	1	4	63	61	138,780,000
Pennsylvania	114*	131*	103*	113*	113	107	....	....	....	....	17,256,000
Texas	468	421	439	388	320	314	301	291	327	310	476,560,000
West Virginia	29	37	22	31	6	17	6	4	6	7	3,780,000
Wyoming	1	4	1	2	2	4	1	1	1	2	32,778,000
Total	1517	1517	1349	1348	795	757	453	439	613	612	1,383,280,000

*Includes water-intake and pressure wells.

Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

PETROLEUM ENGINEER EDITION

Conservation Note to Owners of Baash-Ross Roller Kelly Bushings

AN OUNCE OF GREASE WILL SAVE *TONS* OF STEEL!

Your Baash-Ross Roller Kelly Bushing is one of the hardest working equipment-savers you have on your rig. It prolongs the life of your Rotary Table your Drill Pipe your Swivel and your Wire Line your Drilling Bits

Its maintenance is simple—regular lubrication...and pays BIG returns in longer equipment life!

ADDITIONAL MAINTENANCE HELPS FOR YOUR ROLLER KELLY BUSHING

USE A KELLY WIPER. We strongly recommend the use of a Kelly Wiper on our Roller Kelly Bushings. It helps to keep mud and water out of the bearings, thus prolonging their life and service. In addition, it helps you keep the rig floor free of slippery mud, saves wash water and reduces mud dilution. Wipers are available from either Baash-Ross or Patterson-Ballagh.

KEEP YOUR HEX BUSHING ADJUSTED. Baash-Ross engineers have incorporated a valuable performance feature into the Hex Roller Kelly Bushing . . . a simple method of quickly adjusting the Bushing for the close fit that is so important with modern Hex Kellys. First, determine in fractions of an inch how much play you want to take out of your Bushing. Then simply unscrew the lip ring, lift out the cages and remove one or more of the adjusting shims. The working diameter of the Bushing is reduced $\frac{1}{32}$" for each shim removed, so it's easy to know how many to take out if you first determine the amount of play. After the shims are removed, replace the cages and tighten the lip ring. That's all there is to it!

REVERSE THE PINS. Another unique feature in Baash-Ross Roller Bushings is this. . . There is no driving pressure—therefore no wear—on the back side of the roller pins. If these pins have become worn on the front side, you can simply turn them so that the unworn back sides are to the front and you get new life from your pins. This cuts maintenance still further and insures peak performance *longer* without replacements!

●

We at Baash-Ross are vitally interested in seeing that you get ALL of the long life and smooth, efficient performance we build into every Baash-Ross Roller Kelly Bushing. If you have any questions on its maintenance or servicing, please feel free to write our engineering department any time. Your inquiry will receive prompt attention. *Or call the Baash-Ross service man near you!*

All lubrication fittings are centrally located, easy to reach!

WHEN you bought your Baash-Ross Roller Kelly Bushing, you not only bought smooth performance no other bushing can match—but *unusually long, trouble-free life*, as well. Typical is the Baash-Ross Roller Bushing that drilled more than 183,000 feet of hole before coming in for servicing... equivalent to more than *thirty-six* 5,000-foot wells without maintenance of any kind except lubrication!

That's the kind of long, trouble-free life built into these bushings, and the key to such performance can be summed up in two words... *proper lubrication.* To make greasing as simple as possible, ALL lubrication fittings are conveniently centralized on the top of the bushing where they're easy to reach. Each of these fittings (8 on the square-kelly bushing, 12 on the hex) controls an independent duct to each roller, insuring direct, *positive* lubrication to every bearing.

We've made lubrication easy and fool-proof. Now all you have to do is follow these rules...

- ***Pump grease into every nipple on the bushing each time you lubricate the draw-works —at least once each day. You can't over-lubricate the Bushing, so it's better to have too much than too little grease.***
- ***Use a water-proof grease. Such a grease will seal the bearings against the entry of water, mud and dirt . . . and gives much better protection than ordinary greases.***

Simply by keeping your bushing lubricated you'll keep it rolling smoothly for many thousands of feet of trouble-free service. For additional maintenance suggestions, see column at left.

MAJOR *Refining* ACTIVITIES

A NEW plant to produce approximately 48,000,000 lb. of semi-reinforcing carbon black per year is planned by the United Carbon Company for construction at Ryus, Kansas. The plant will consist of four units costing about $1,500,000 not including wells, lines, and other plant supply facilities. Construction of the plant was requested by the War Production Board because of the need for carbon black to mix with synthetic rubber for tire and other war material manufacture.

The Kansas Corporation Commission has approved application of United Carbon Company to use an additional 24,000,000 cu. ft. of gas from the Hugoton gas field for the manufacture of carbon black.

The Farmers Union Central Exchange, Inc., has purchased the Independent Refining Company plant at Laurel, Montana, for $750,000 cash in addition to the inventory value, which is expected to increase the consideration to about $1,000,000. Light oil from the Dry Creek field and black oil from the Garland-Byron district is supplied the plant by contract with the Ohio Oil Company.

More than 20 plants are in operation, under construction, or being designed to operate the Universal Oil Products Company hydrofluoric acid alkylation process. Capacity of the alkylation plants is a military secret as purpose of the process is to produce alkylate, an essential and highly potent constituent of 100-octane aviation gasoline.

The alkylation reaction combines *iso*paraffinic and olefinic hydrocarbons in the presence of hydrofluoric acid and was discovered in Universal Oil Products Company laboratories during the depression years. The process was quickly developed to commercial status when the large demand for fighting aviation gasoline was foreseen.

Construction of facilities to produce butadiene, a synthetic rubber ingredient, in a converted refinery at Texas City, Texas, has been stopped by the War Production Board.

Revocation of priority ratings previously made to the Pan-American Refining Corporation was ordered on recommendation of Petroleum Administrator Harold E. Ickes.

Discovery that the shortage of critical valves, pumps, motors, and other equipment was so severe that the program for "quick" butadiene could not possibly contribute much to the synthetic rubber program this year caused a number of conversion projects to be cancelled.

Rebuilding of the Casmalia, California, refinery of O. C. Field Gasoline Corporation, damaged by fire last October, is now under way. Operation of the plant is expected to begin in the near future.

According to an announcement, The Pure Oil Company, The Texas Company, Mid-Continent Petroleum Corporation, and Anderson-Pritchard Oil Corporation have negotiated a contract with Otha H. Grimes, natural gasoline manufacturer of Tulsa, Oklahoma, for construction of a 5,000,000 cu. ft. absorption gasoline plant on the Jackson lease in the Pauls Valley pool of Garvin County, Oklahoma.

A statement by Grimes said that the plant would process the high-pressure gas produced from both the Pennsylvania and Ordovician formations in the pool, and produce high-test natural gasoline, butane, and propane. Residue dry gas will be disposed of to the Lone Star Gas Company.

Approval of the plant was given only recently by the War Production Board, although application was made early in November, 1942. The basic portion of the plant will be an idle plant owned by Grimes in Michigan, which will be dismantled and shipped to Pauls Valley. An estimated three months will be required for erection of the plant.

An announcement by Frank Phillips, chairman of the Phillips Petroleum Company, stated that the Petroleum Administration for War has approved a company project for construction of a large unit employing cycloversion, the newly announced catalytic process for production of aviation gasoline.

"This new cycloversion unit will convert automobile gasolines or other petroleum distillates into products which, when blended with other components, will impart greatly improved flight performance to finished aviation fuels," Phillips said.

Capacity and location of the new catalytic cracking unit was not released, but it was understood that it would be a substantial addition to the Nation's aviation gasoline program.

The proposed butadiene plant in Wood River, Illinois, has been cancelled because of shortages of certain critical components, Col. Bradley Dewey, Deputy Rubber Director, has announced.

"This plant," Col. Dewey said, "was scheduled to be made by converting a refinery of the Standard Oil Company of Indiana. We were glad to accept the recommendation of the Petroleum Administrator for War that this plant be converted, because we have faith in the Houdry process and in the company, and because we approved the location.

"The plant, however, was scheduled originally because it was believed it could be completed by May 15. When, because of shortages in various critical components particularly some turbo-blowers, it became apparent that the plant could not be completed before November, we had to cancel the operation."

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended February 27, 1943
A.P.I. Figures

(Figures in thousands of bbl. 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Production	Total Gas and Fuel Oil Stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	88.7	1,671	68.4	9,949	65,556
Appalachian	84.8	161	91.0	818	4,313
Ind., Ill., Ky.	85.0	718	88.5	4,417	26,480
Okla., Kans., Mo.	80.1	344	82.7	2,160	10,342
Rocky Mountain	48.0	92	62.6	631	2,987
California	89.9	723	88.5	4,660	86,558
TOTAL U. S.—B. OF M. BASIS FEB. 27, 1943	86.2	3,709	77.1	22,635	196,236
TOTAL U. S.—B. OF M. BASIS FEB. 20, 1943	86.2	3,694	76.8	21,858	196,010
U. S. B. OF M. BASIS FEB. 28, 1942		3,672		22,728	229,533

(a) Finished 82,887,000 bbl.; Unfinished 10,270,000 bbl.
*At the request of the Petroleum Administration for War.

P 422.141.

THE Petroleum Engineer

MARCH, 1943

Drilling Well Inside City Limits Made Noiseless and Safe

☆ All surface equipment insulated against noise and fire—Cellar controls arranged for any emergency

by Wallace A. Sawdon

Pacific Coast and Foreign Editor

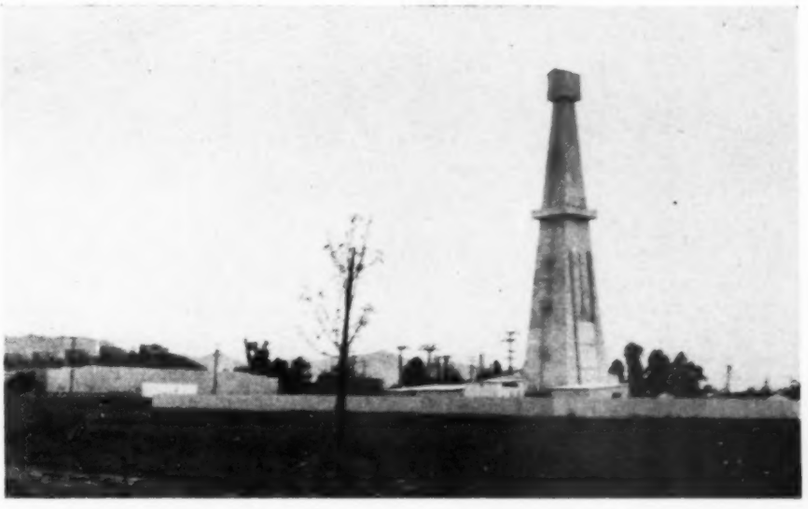
THERE is a constantly increasing drain on the oil reserve of California—a state that, because of its geographical position, is vitally important as a source of petroleum products most readily accessible to the Pacific war front. Every favorable structure in this area must be explored in order to agument the reserve and make available all the oil possible. It was for this reason that permission was finally granted and materials released by the War Production Board for the drilling of a well on what is known as "Gilmore Island" in the heart of the City of Los Angeles.

It was natural that objections should be made by property owners to the drilling of a well in the proximity of a residential section, and before permission was granted the Los Angeles City Planning Commission asked the Petroleum Administration for War if the project was deemed essential. After being assured that "It is of vital importance that all possible sources of oil in California, in Los Angeles County, and in the City of Los Angeles, be explored as soon as possible," permission to drill was granted by the City Council to Shell Oil Company, Inc., holder of the lease. The first well was spudded-in as Verne Community No. 1 on January 30, 1943.

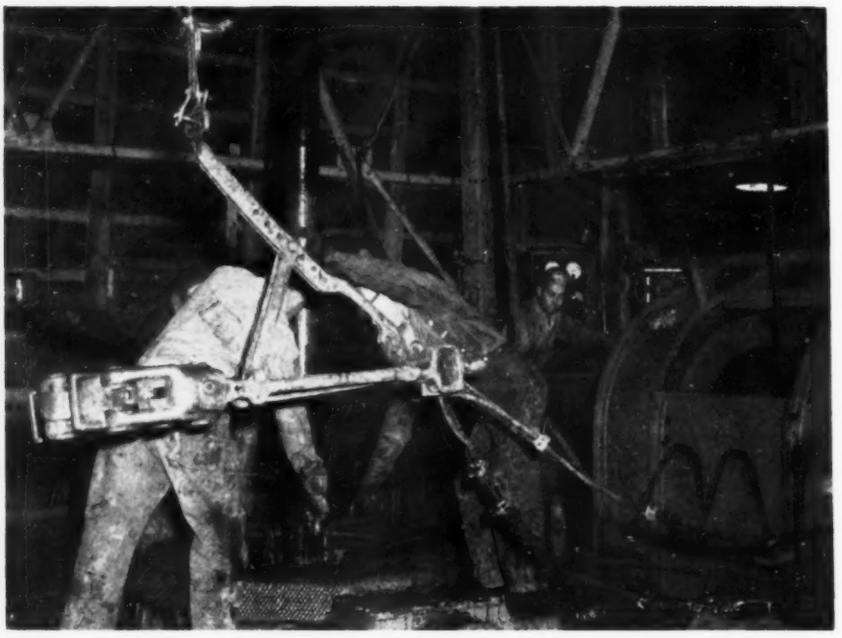
Surface Equipment Insulated

Because of the location and the restrictions imposed, the surface equipment for this well had to be insulated against noise and fire hazard. The derrick is of standard steel construction but, after erection, was first enclosed with a wooden framework as shown in the accompanying illustrations. The inside of the framework was covered with chicken wire to hold a thick covering rock wool, which was then placed within the frame structure to insulate against sound. Outside of the rock wool sheets of transite mineral board were attached to the wooden members to make the structure fireproof as well as sound-proof. This combined insulation covers the entire derrick structure including the engine house. The dog house with lockers is placed on the ground away from the derrick floor to provide greater convenience for the men.

The only openings in the derrick structure are a small one at the top above the crown block and another on the side about derrick floor level for bringing in pipe, tools, and materials. Electric lights must, of course, be used day and night but reflectors prevent



General view of Shell's Verne Community No. 1 well



A scene on the derrick floor while drilling. The interior of the insulated structure can be seen

any upward glow through the small opening above the crown block. Two fans on the derrick floor circulate the air and keep it moving upward through the opening at the top. The side opening is covered with a vertical sliding door insulated like the rest of the building. As there are objections to opening this door at night, 90-ft. stands of drill pipe are made up during the day and placed on the rack within the derrick for use when needed. A "mouse hole," in addition to the rat hole, has been provided to take one 95-ft. stand of pipe.

Pump House Enclosed

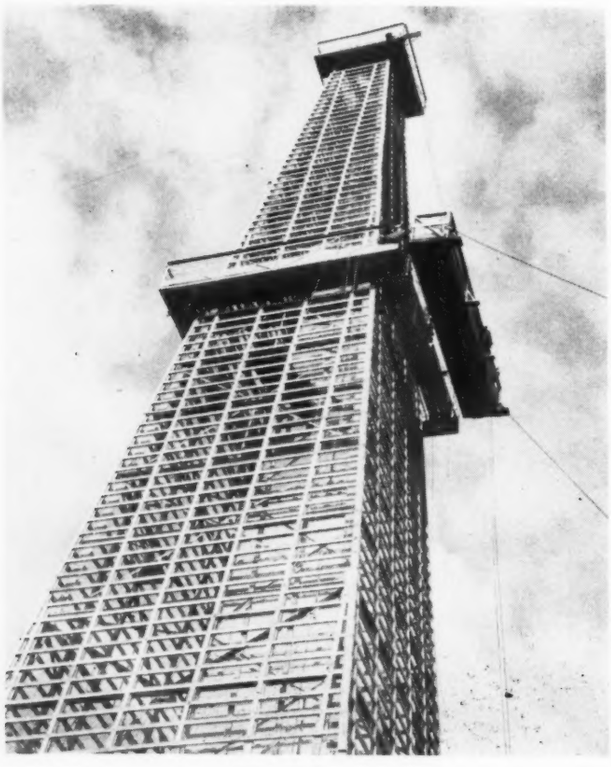
The pump house is enclosed with the same construction materials as the derrick and contains two power pumps—a 7¾-in. by 16-in. and a 7¼-in. by 18-in. These are driven by V-belts from two 150-hp. and two 125-hp. electric motors, respectively. The motors are outside the insulated pump house (through the wall of which the enclosed V-belt drives extend) because the Los Angeles Fire Department would not permit their placement in an insulated building. The motors, with grids and control equipment are, however, sheltered by a roof.

The mud returns pass over two shaker screens, which also are housed in rock wool although transite mineral boards are not used, as there is no fire hazard in this building.

Drilling Equipment

The drilling equipment consists of a heavy-duty drawworks powered by two 200-hp. electric motors. The rotary table is direct-driven through a 2:1 reduction gear by an individual 250-hp. electric motor. This motor is enclosed in a steel housing to prevent water getting on it, a fan circulating air through the enclosure and downward below the derrick floor. This air then

The steel derrick is enclosed in a wooden framework preparatory to the installation of rock wool and transite mineral board



The finished derrick, insulated with rock wool covered with transite mineral board

passes upward through the floor and out the top of the derrick, the circulation being augmented by another fan placed in the engine house. The reduction gear between the motor and the rotary machine provides speeds additional to those given by the motor control.

All motors used in the drilling and pumping operations can be controlled from the driller's position. There are also connections to the master switch that can be thrown from the driller's positions at the brake and cat head and from the cat head position on the opposite side of the drawworks.

Because of the insulation against sound a speaker system has been installed. By this means communication can be carried on between the driller, the man in the derrick, the man in the pump house, or the attendant at the gate.

Cellar Equipment

The cellar hook-up insures safety in any emergency. At the bottom of the hook-up is a full-closing cellar control gate valve that serves as a master gate. Above this is a cellar control gate valve equipped with rams for closing around pipe. These gate valves are operated by remote manual control. A mud cross with outlet for returns is on top of the upper gate valve and above this is a blow-out preventer with hydraulic pack-off. The source of hydraulic pressure for operation of this pack-off is the city water main and a high-pressure pump. In addition, two CO_2 bottles, which can deliver a pressure of 2000 lb. per sq. in., are available for operation of this equipment.

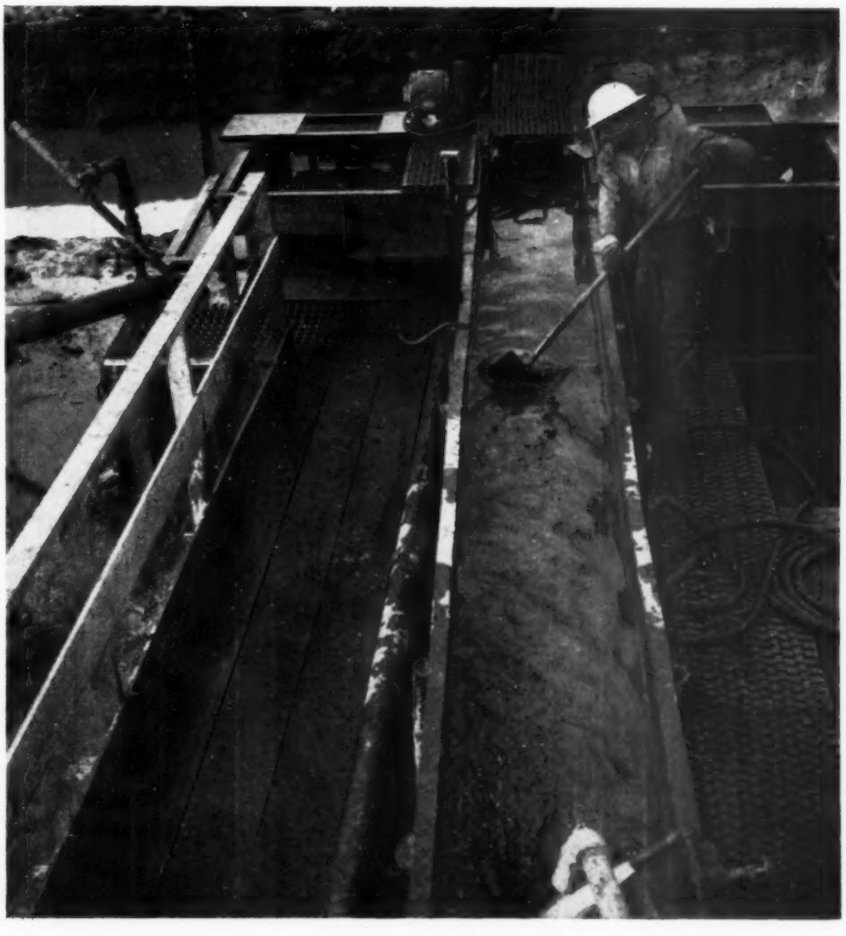
Verne Community Lease

The Verne Community Lease is part of an old rancho and was named in honor of Jules Verne, author of "20,000 Leagues Under the Sea." It covers approximately 300 acres comprising what is locally known as "Gilmore Island." On this "Island" are the Hollywood Baseball Park; the Gilmore Stadium for automobile races, football games and other athletic events; the Pan-Pacific Auditorium; the site of the new Metropolitan Life Insurance Company's extensive housing projects now in the process of construction; public school grounds; some acreage belonging to the University of Southern California, and public markets. One side of the lease extends parallel to and one block away from Wilshire Boulevard. Surrounding it on all sides is an extensive residential district.

Only a small portion of the Verne Community Lease, on which there are no enterprises, has been set aside as an

Constructing the pump house with the pumps already in place

The shaker screens at the end of the ditch have now been housed over with a rock wool insulated structure



The interior construction of the pump house

operating tract. This parcel containing approximately 19 acres is owned by Shell. The present well is situated in the center of this tract. If oil is found all other wells in the sand will be drilled from this tract by directional drilling methods.

This lease, together with approximately 1500 acres of the surrounding residential district, covers the old Salt Lake field, which produced approximately 70,000,000 bbl. of oil from 350 wells at an average depth of 1200 ft.[1] "This field was discovered in 1905 from oil seepages, drilling reached its peak in 1912, and the last wells were drilled in 1917 before deep drilling technique was developed. There still are eight producing wells in this area, one of them pumping away in the middle of La Cienega Boulevard. These eight wells produce to total of 200 bbl. a day. All are outside the area in which Shell is working."

The present well has passed through the old producing sands, which are greatly depleted. The objective is the Middle Miocene sands from which comes the production of the Inglewood field approximately five miles to the south.

The Verne Community project received the support of the Secretary of the Navy, who stated to the Los Angeles City Council: "The needs of the armed forces of the United States and the war production industries in the Pacific area for petroleum products, make it imperative that all possible sources of new production be examined in an effort to increase California's oil resources. For this reason the Navy Department wishes to support the application for the authority requested."

The Shell Oil Company is offering to drill wells under the 1500 acres of residential property outside the Verne Lease on a royalty basis and if sufficient property owners sign up, this will be known as the Salt Lake Community Lease.

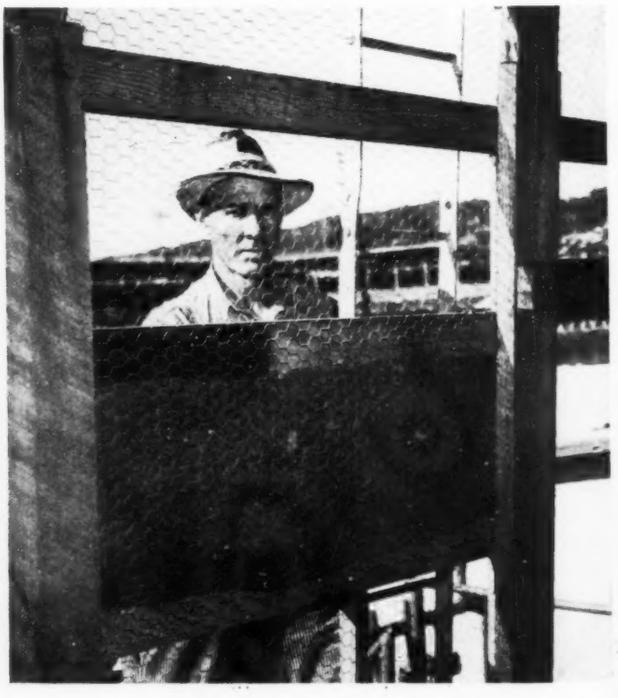
Photographs are by courtesy of *Shell News*.

[1]Statistics and quotations are from *Shell News*, Vol. 5, No. 8, February, 1943.

☆ ☆ ☆

The thickness of the rock wool insulation is shown in this section being examined by Robert J. Kettenburg, Division Engineer, and Albert S. Baptie, Division Superintendent, Shell Oil Company, Inc.

Installing a pad of rock wool in a cell of the wooden framework. Chicken wire holds it in place on the inside. Transite mineral board in panels covering six cells is nailed on the outside



Automatic Control of Feed Water to Boiler

☆ Proper construction and installation of control equipment for efficient boiler operation

PETROLEUM ENGINEER Exclusive Feature

PART 1

by J. A. Campbell

Research and Development Engineer

MANY different principles are utilized in the control of feed water to a boiler to maintain a fairly constant level. There are valves actuated by floats both directly and through pilots; there are inclined thermostatic tubes directly motivating valves, and there are inclined tubes surrounded by a jacket filled with a volatile liquid that controls the diaphragm valve by vapor pressure. Some consist of a steam trap admitting steam pressure to the diaphragm valve. Some operate on the flashing of water through a small orifice. The great majority, however, utilize in some form or other the inclined thermostatic tube. The basic patent on this expired many years ago and the patents now issued are concerned with the method of application to valve motivation.

The inclined tube, usually of brass, Muntz metal, or some other alloy with a high coefficient of expansion, constitutes a very simple and positive means of valve control. In principle it works as follows: An inclined tube is set up alongside the boiler so that the water level cuts across it. One end of the tube, usually the lower end, is anchored, the other end being left free. The lower end of the tube is connected by piping to the boiler at a point below the water level; the upper end is connected in a similar manner, but with some flexibility, to the steam space above the water level. As the level drops in the boiler, it drops in the tube, the same amount vertically; the distance the level will change lengthwise of the tube will depend on the slope of the tube. The water in the lower end of the tube is more or less "dead", and will cool off by radiation of the heat through the walls of the tube to atmosphere. If the water level in the boiler rises the cool water rises in the tube and comes in contact with that portion of the tube which was in contact with steam and cools it considerably. This cooling of the tube causes it to contract in length. Conversely, should the water level in the boiler drop, the tube will be heated and will lengthen through expansion. All that is necessary to make the controller complete is to connect the free end to the stem of a valve in the feed line in such a manner that when the tube expands it will open the valve. There are as many ways of doing this as there are inventors—and there is no scarcity of inventors.

J. A. CAMPBELL

received his literary degree from Ogden College, Bowling Green, Kentucky, where he majored in mathematics—Graduated from Yale in civil engineering in 1913 and taught mathematics at Kingsley School—In 1916 he went to California and joined the staff of the Union Oil Company, doing research and development work, design, and construction and in 1922 became engineer of gas plants—In 1923 he helped organize the Lomita Gasoline Company of Long Beach, and soon became vice-president of the company—In 1924 he organized the J. A. Campbell Company and for the next 8 years was engaged in contract building of gasoline absorption plants—In 1933 he formed the J. A. Campbell Research and Development Company and has since been engaged in this type of work—Campbell is also vice-president of Petrolane, Ltd., manufacturers of liquid petroleum gas; secretary-treasurer of the L. P. G. Corporation; vice-president of the Union Die Casting Company of Los Angeles; secretary-treasurer of the Long Beach Blue Print Company, and a director of the Rice Ranch Oil Company.

The writer has in past years installed dozens of different types of thermostatic regulators of various makes and has had an opportunity to observe their performance. Although their principle was sound so little movement was available for valve motivation that their performance was impaired. It was decided to do some research work to determine whether more movement could be obtained.

Experimental Work

As the effectiveness of a thermostatic tube depends upon its terminal temperature difference, the initial move was to install a simple tube, equip it with thermometers, and determine this difference. The tube selected was 42 in. long, set with a slope of 1 in 12 so as to cut the water level at its mid point. A horizontal return tubular boiler of 150 hp., 150-lb. working pressure, carrying a water level of 3½ in. in a 12-in. glass was used in the experiments. The average temperatures taken hourly over a 72-hour period, were 356°F. at the top of the tube and 268°F. at the bottom. This 88° difference seemed small and accounted for the poor performance of the thermostatic tube. Before attempting to correct an undesirable condition, the causes must be determined. Obviously, in this instance, not much could be done to raise the upper temperature because it was within 4° of the saturation temperature of the steam, so it was necessary to find out why the lower end temperature was high. There were two obvious reasons. First, the steam lead, a small uninsulated pipe connecting the upper end of the tube, as is usual, caused considerable steam to condense, and the condensate had no place to go except downward through the tube, tending thereby to keep the lower end warm. Second, the temperature of one end of the brass tube was 356°F. and brass, being an excellent conductor of heat, the other end of the tube became quite hot. The small surface area of the tube was not sufficiently effective in dissipating this conducted heat. Two obvious improvements were immediately made. First the condensate was bypassed around the

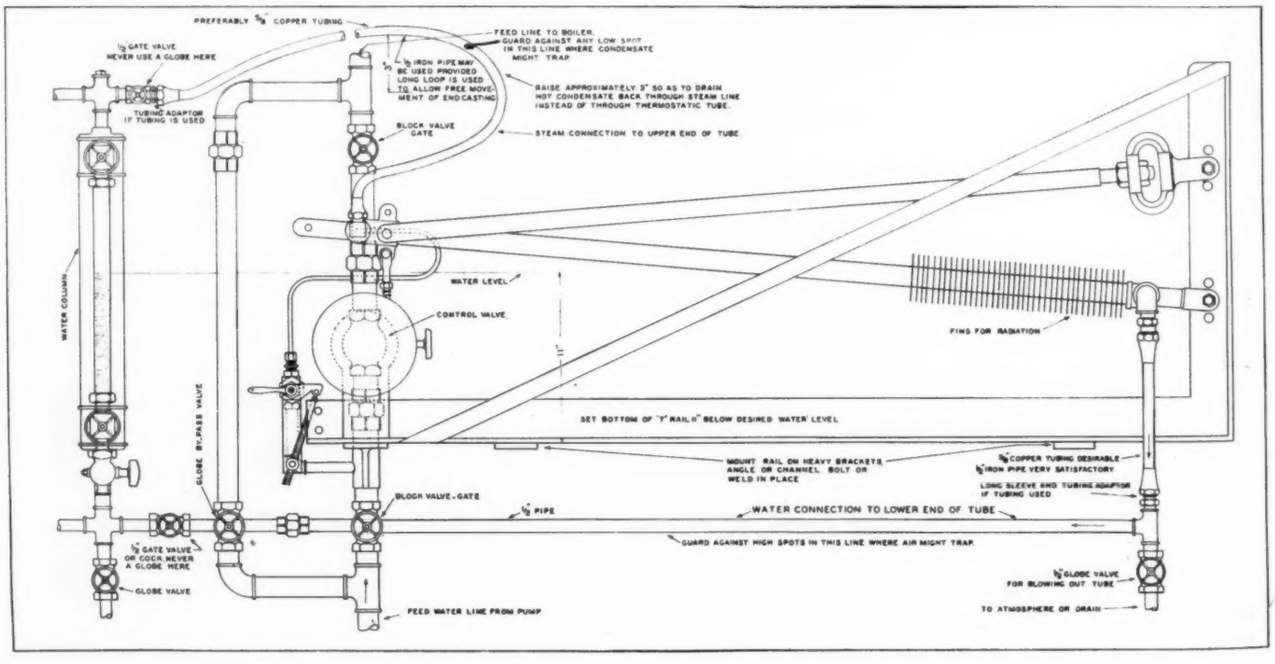
tube and connected into the return water lead. This was done very simply by using a T on the steam lead to the movable casting and connecting the lower "run" of the T by means of a piece of flexible copper tubing to some point in the water return. This simple change dropped the lower end thermometer reading 31°. The other improvement was that of greatly increasing, by the use of fins, the radiating surface of the lower end of the tube. The experiments on finning extended over a period of six months; a drop of 60° was obtained with the first crude fins tried. Finally, by using a very thin fin of 3-in. diameter, corrugated for strength and properly spaced, the temperature exceeded 100°F. These two improvements resulted in a tube twice as effective as the simple tube.

Cantilever Principle Adopted

Even so it was not believed that the expansion of the tube thus obtained would afford enough movement for the direct motivation of the valve stem to control the feed to a boiler except through the use of a large valve. A valve barely opened causes an excessive pressure drop and also wire-drawing. To multiply the available movement due to expansion, the cantilever principle was adopted. This is effected by anchoring the lower-end casting to a vertical frame member with a pivotal joint and anchoring the upper-end casting in a similar manner by means of a rigid 2-bar member. This member, which is very nearly the same length as the tube, anchors to the vertical frame member 7 in. above the point where the lower-end casting anchors. This produces a rigid triangle. A triangle, as is well known, is the only geometrical figure the shape of which cannot be changed without changing the length of one of its sides. As the ratio of the length of the long sides of this triangle to the short 7-in. base is 6 to 1, a change in the length of the tube will raise or lower the end casting approximately six times the amount of that change. The force made available by the expansion of metal is enormous and limited only by the elastic limit of the metal. The features of the cantilever principle are threefold. One, it multiplies the movement due to expansion or contraction. Two, the force is just as powerful in either direction, and in pulling down on the valve eliminates the use of a weight for this purpose. Three, when the level in the boiler drops, the water runs down the tube and the resulting expansion raises the movable end of the tube and causes the water to run down farther. Conversely, a rising level cools the tube, lowers the end casting, causing the water to cool more of the tube than would be possible if the slope of the tube were fixed.

The writer has found that many operators and engineers are under the impression that it is solely the change in temperature of that small section of the tube that changes from a water contact to a steam contact or vice versa, that produces the movement. This is incorrect. As the water level runs down the tube, the whole range of temperatures from one end to the other will change. To demonstrate this an improved model having a thermometer well in each end of the tube was set up. A third well ½ in. below the center and a fourth 3 in. below that completed the set-up. A gauge glass was run full length of the tube and the level held exactly in the middle. Temperature readings from the upper end downward were 358°F., 297°F., 268°F., and 147°F. Next the level was run 3 in. down the gauge glass paralleling the tube. This corresponds to a drop of approximately ¼ in. in the regular boiler glass. The new readings were 358°F., 324°F., 288°F., and 160° F. Anyone sufficiently interested to do so can take these two sets of figures and make many interesting observations. For instance, one can take the co-efficient of expansion for red brass, which is 0.0000105, and by multiplying by the corresponding lengths of the different sections between the thermometer wells and by the temperature changes, determine that the upper or steam section expanded 0.00074025 in. The middle 3 in. expanded 0.0031085 in. and the lower portion or water-filled section expanded 0.0029765 in.—the total being a trifle less than 7/1000 of one in. Had the water level in the boiler dropped vertically ¼ in., the water level would have dropped (lengthwise) in the tube 3¼ in. because the fixed length of the cantilever bar increases the slope with expansion. Roughly this

Instructions for installing feed-water controller

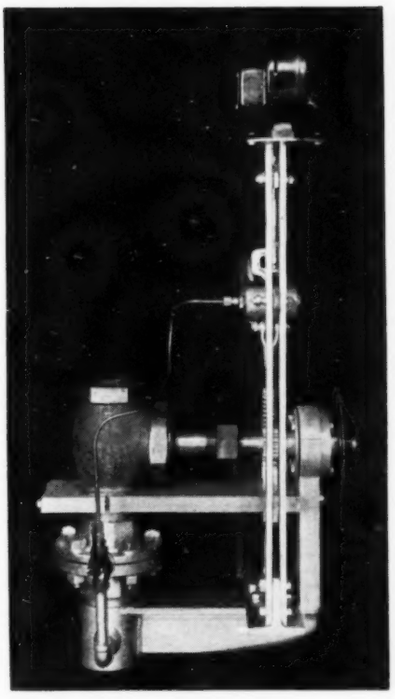

PREFERABLY ½" COPPER TUBING
FEED LINE TO BOILER. GUARD AGAINST ANY LOW SPOT IN THIS LINE WHERE CONDENSATE MIGHT TRAP
½" GATE VALVE. NEVER USE A GLOBE HERE
½" IRON PIPE MAY BE USED PROVIDED LONG LOOP IS USED TO ALLOW FREE MOVEMENT OF END CASTING
RAISE APPROXIMATELY 3" SO AS TO DRAIN HOT CONDENSATE BACK THROUGH STEAM LINE INSTEAD OF THROUGH THERMOSTATIC TUBE.
TUBING ADAPTOR IF TUBING IS USED
BLOCK VALVE GATE
STEAM CONNECTION TO UPPER END OF TUBE
WATER COLUMN
WATER LEVEL
CONTROL VALVE
FINS FOR RADIATION
SET BOTTOM OF "F" RAIL "F" BELOW DESIRED WATER LEVEL
GLOBE BY-PASS VALVE
MOUNT RAIL ON HEAVY BRACKETS, ANGLE OR CHANNEL, BOLT OR WELD IN PLACE
½" COPPER TUBING DESIRABLE ½" IRON PIPE VERY SATISFACTORY
LONG SLEEVE AND TUBING ADAPTOR IF TUBING USED
BLOCK VALVE-GATE
½" PIPE
WATER CONNECTION TO LOWER END OF TUBE
GUARD AGAINST HIGH SPOTS IN THIS LINE WHERE AIR MIGHT TRAP
½" GATE VALVE OR COCK. NEVER A GLOBE HERE
GLOBE VALVE
½" GLOBE VALVE FOR BLOWING OUT TUBE
TO ATMOSPHERE OR DRAIN
FEED WATER LINE FROM PUMP

would add one-twelfth to the total, or about 0.045 in. for a total vertical movement of the end casting after multiplying by six, which is the mechanical advantage of the cantilever principle for this particular set-up. The true mean temperatures, to be sure, are not the arithmetical means that have been used here; however, the actual movement of the end casting checks these calculations as closely as can be measured.

The total movement of the end casting from a cold tube to one filled with steam at 150-lb. pressure is ¾ in. This wide range of movement lends itself admirably to the motivation of a lever type of valve by attaching the end casting to the lever by means of a rod. This rod is in two sections connected with a "shock absorber" consisting of a spring that compresses and takes up the strain when a boiler is shut down and the tube is cold and fully contracted.

Throttling

A globe type valve is ideal for throttling and because of the rotary motion it is much easier to pack the stem so it will not leak. Almost three years ago the writer decided he had sufficient movement available in his cantilever design of controller to translate the vertical movement into rotational movement by means of a rack rotating a pinion gear attached to the valve stem. For the first experiments, a quick opening globe valve with a quadruple thread screw was used.This gave a fast travel to the valve stem. One large oil company interested in this improvement asked whether the screw could not be eliminated or its contact with the water obviated and so remove any possibility of its "liming-up." This was done by using a phosphor-bronze cam in the shape of a short thick wall cylinder with a helical slot accurately milled in each side. The



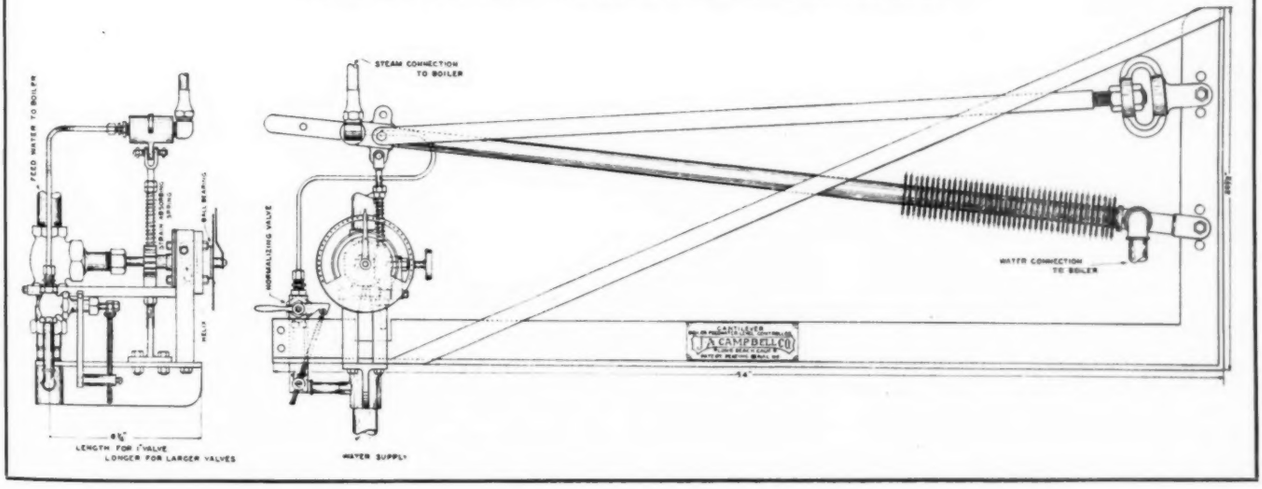
End view of feed-water controller showing normalizer valve

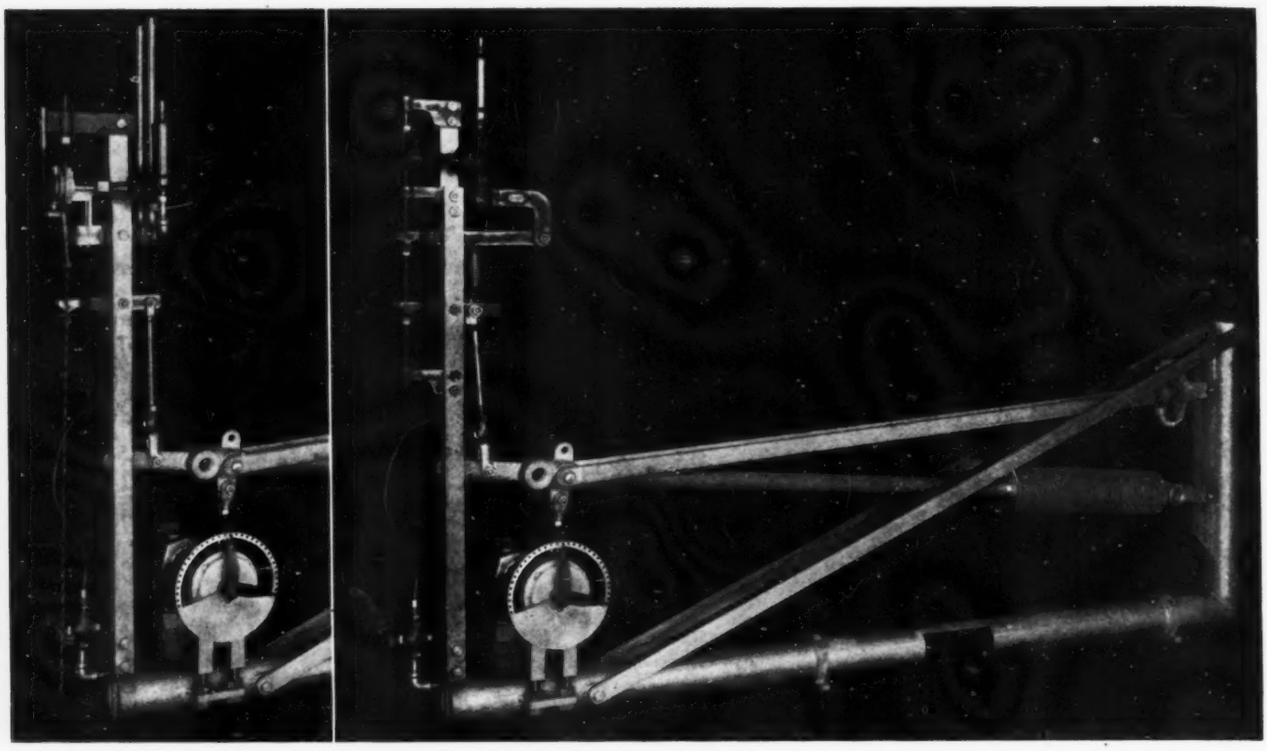
valve stem is now a simple rod carrying a rotor slightly smaller than the inside of the helical cam. The pinion is silver-soldered to this rotor, which in turn is fastened to the stem by means of a set-screw. This, however, is merely for convenience in assembly because a ¼-in. drill-rod pin passes through a reamed hole in the rotor and through the stem, thus definitely assuring the rotation of the stem with the pinion. The pin is sufficiently long to extend almost the full thickness of the cam on each end, on each of which is an aluminum bronze roller that is a running fit in the ⅜-in. helical slot of the cam. These slots are of sufficient pitch to give a 1-in. valve full opening with only a ¼ turn. Ordinarily on control a valve will ride from 1/64 in. to 3/64 in. open. The rack and the pinion each have a ¾-in. face, which permits the pinion to slide across the rack as the valve stem advances or recedes, still maintaining proper engagement. To insure smooth action of the rack and pinion and greatly lengthen the life of the packing, a ball bearing is placed on the shaft, having its race in a cap mounted on the cam housing. In order to insure initial and lasting alignment of the stem through the bonnet bore and the bearing, a heavy bar cross member has a hex slot cut in one end; the hex of the bronze body screwed valve is securely held in place by a corresponding hex-slotted cap with cap screws. The other end of this cross member is cap-screwed to the cam housing. Another heavy cross-bar also bolted to the two legs of the cam housing has welded to its other end a hydraulic pipe coupling to which the valve is connected with a union in between. These members are jig made and accurately sawed out and filed by means of contour sawing and filing machines. So rigidly is the valve held in place that it is never thrown out of alignment when making up the piping.

Valve Opening Indicator

The rotational movement of the valve stem has afforded an excellent opportunity for incorporating a valve opening indicator. There is a disk fastened to the bearing cap with a series of holes drilled near its circumference. The indicator is a metal hand secured to the shaft by means of a hub with set screw. This indicator is factory-set pointing to the extreme clockwise hole on the disk for closed valve position. The holes are accurately spaced so that each space

Feed-water controller with globe valve having outside screw





Both cantilever boiler feed-water level controllers shown here are of the 1-in. rotary type. The one at the left is equipped with a snap-action fuel cut-off, manual reset. The one at the right has a hi-low steam whistle alarm attachment

represents 1/64 in. of valve stem travel. This hand tells at a glance the exact opening of the valve under all conditions.

As a recent improvement another indicator hand has been added secured to the end of the shaft by a machine screw. This indicator hand is enameled green to distinguish it from the other, which is black. This second hand may very readily be set in a vertical position for normal load. The operator can tell at a glance whether the boiler is steaming heavier or lighter than usual by noting the inclination of the hand, whether to the left or right of vertical. A further advantage of this indicator will be discussed later.

Blowing Out the Tube

Despite one serious objection to the thermostatic tube as a control for feed water, it has so many outstanding superiorities that it is the means of control for more than 80 percent of the regulators on the market. The objection lies in the necessity for periodically blowing out the tube to free it of sludge that might bake into scale and lower its sensitivity or even plug it up. This blowing operation is accomplished by opening, to atmosphere, a valve teed off of the water lead connecting the boiler with the lower end of the tube. Some operators, when blowing, close the valve on this lead next to the boiler, but this is not necessary as a thorough purging of the tube is effected by leaving it open because steam is much more mobile than water, due to its lower density. In either case, when the tube is blown, all the reserve of cool water in its lower end is blown out and the hot water equalizing back from the boiler is just as hot as the steam, consequently the tube is fully expanded and the valve is opened to its maximum. The result is that a lot of relatively cold water is forced into the boiler at a much higher rate than it can be evaporated. This will drop the pressure on the pump discharge line, causing the pump governor to open and speed-up the pump. This also means that the steam pressure will drop, causing the fuel governor to open, resulting in inordinate firing of the setting. The level in the boiler will rise from 1½ to 3 in. until the tube has cooled sufficiently through radiation to the atmosphere to contract and close the valve. This entire procedure is hard on equipment, wasteful of fuel, and has caused many accidents because boiler tenders have shut off one of the block-valves to keep the water from going so high and have failed to open it.

Normalizer

All these complications are completely eliminated by the use of the "normalizer", which is a spring-loaded normally closed valve with its take-off from the feed line upstream from the control valve. The lever handle of this valve may be equipped with a chain or wire extending downward to ground reach. Just as soon as the blow-valve is closed the operator pulls the lever of the normalizer, which bypasses a small stream of feed water around the control valve through the normalizer valve and into the upper end of the tube by means of a flexible connection of copper tubing. As this water is nearly always from 150 to 200°F. cooler than the tube, its passage the full length of the tube will very quickly cool the latter. This water passes into the boiler by way of the water connection to the regulator. The operator, while holding the normalizer valve open, keeps his eye on the green hand, which quickly starts moving back toward normal position. As soon as it is in a vertical position, the operator releases the handle and the spring closes the valve. This entire operation requires only from 10 to 15 seconds, a time interval so short that the fire is undisturbed and the water level not changed ⅛ in.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer*.

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Absorber Fabricated From Obsolete Materials[1]

PETROLEUM ENGINEER Exclusive Feature

☆ Two discarded vessels combined to provide absorber for extraction of lighter hydrocarbons

by L. L. Dresser

Dresser Engineering Company

A major oil company was recently faced with the necessity of installing a 20,000,000 cu. ft. per day absorber for the extraction of lighter hydrocarbons. To complicate matters, under present conditions, months would have been required to obtain the critical materials necessary to fabricate a new vessel. In looking through their inventories, two 16-year-old, 6-ft. by 36-ft., 60-lb. working pressure, obsolete absorbers were discovered. These vessels had been discarded some time previously because their design did not enable them to recover the lighter hydrocarbons now so necessary during the war emergency.

The company, of which the writer is owner, was approached by the oil company and asked to advise on the possibility of combining these two vessels into one, redesigning and rebuilding them in such a way that the redesigned vessel would meet their present needs. Investigation revealed that these absorbers were fabricated from ⅜-in. steel throughout, including heads. The rebuilt vessel would have to stand a working pressure of 100 lb. per sq. in.; therefore, it would be necessary to replace the ⅜-in. heads with ⅝-in. steel.

[1]Paper by courtesy of James F. Lincoln Arc Welding Foundation.

To combine the two vessels into one, it would be necessary to remove both heads and the skirt from one vessel; on the second vessel to remove heads and cut the body into three sections so that they could be rearranged in the combined vessel without the loss of any tray surface. To avoid buying new heads, two second-hand, 6-in. diameter, ⅝-in. thick tank heads were found that could be used to replace the original heads.

The engineering company was authorized to proceed with the redesigning and refabricating of these two vessels into a combined vessel, 6 ft. by 70 ft., of 56,000-lb. total weight. In refabricating the vessels, which had been originally welded with bare rod, Type S6044, 300-amp. Lincoln Shield Arc, gas-driven welders, and Fleetweld No. 5 electrodes were used. No difficulty was encountered in fusing into the old material, even though it was highly impregnated with sulphur. When the work was completed it was found that the cost of reconstructing was approximately $1750. The scrap metal value on the two vessels, based on $6.00 per ton, was $168. That, plus the cost of refabricating, made the actual cost of the redesigned vessel $1918. A new vessel, if it could have been obtained, would cost not less than $7500; therefore, the cash saving to this oil company amounted to $5582.

L. L. DRESSER

attended the Tri-State College of Engineering at Angola, Indiana, and has a B.S. degree in Civil Engineering—As owner of the Dresser Engineering Company he has been engaged in the design and construction of natural gasoline and liquefied petroleum products plants, cycling plants, pipe-line stations, gas booster plants, etc., for the last 16 years.

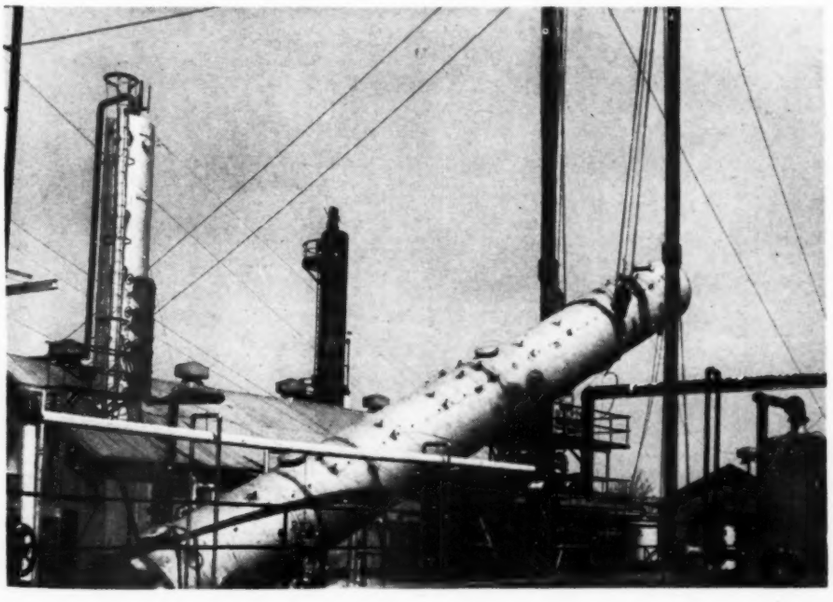
The accompanying photograph of the rebuilt vessel indicates the various cuts and welding required to construct the redesigned vessel.

This piece of equipment is now operating with all the efficiency expected. The refinery is extracting all the lighter hydrocarbons down to within two-hundredths of a gal. per M. cu. ft., which is excellent recovery with any modern vessel.

The owners are so well pleased with the costs and results obtained that they are now planning on rebuilding several other similar vessels from obsolete equipment that normally would be junked. By using no new materials, except electrodes, they will be able to increase their efficiency and capacity without requiring new steel so greatly needed for war requirements at the present time.

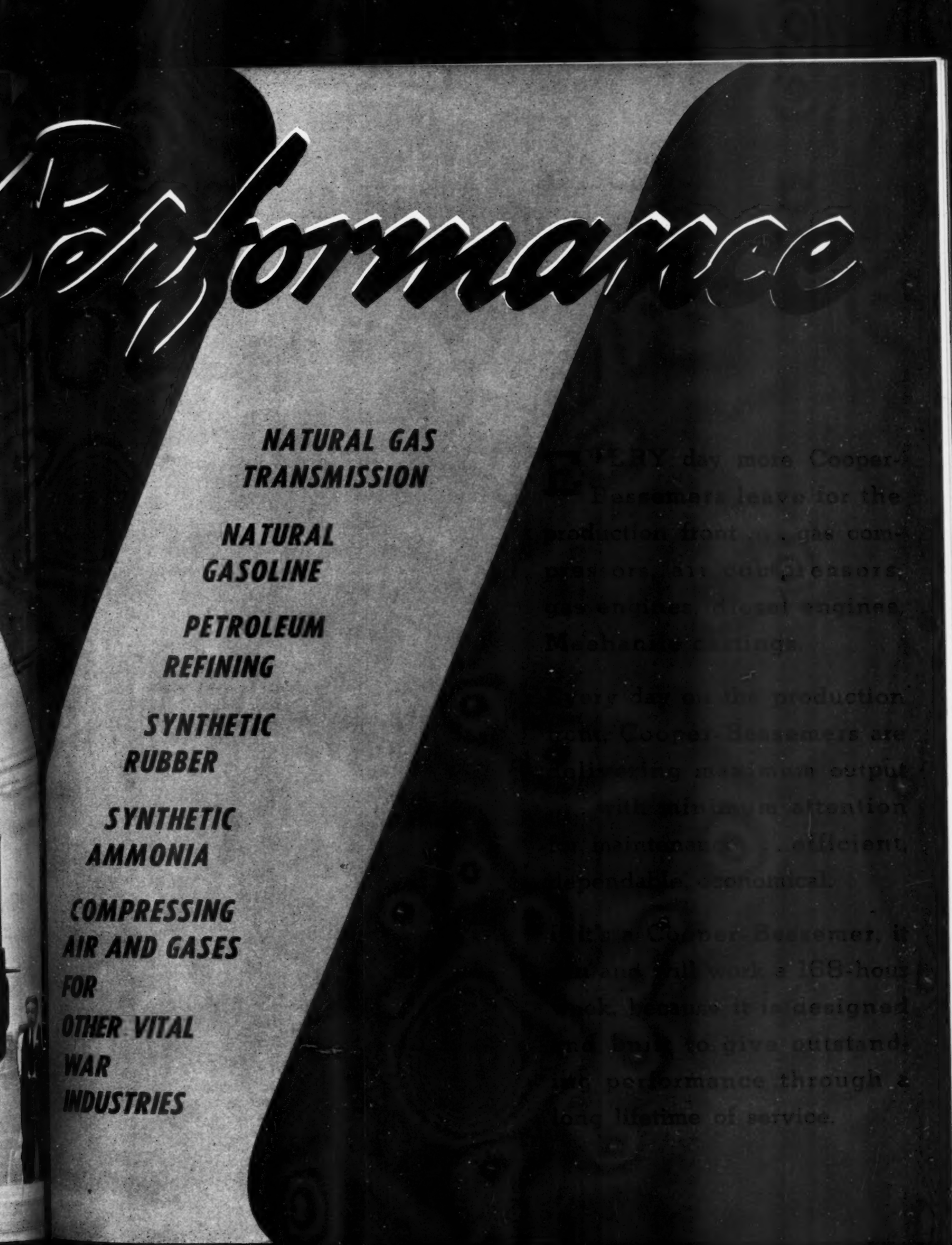
There are, no doubt, hundreds of other instances where similar investment savings could be made; efficiency increased by taking full advantage of modern arc-welding procedure.

☆ ☆ ☆



Erection of the absorber after completion at the plant

New York Washington Bradford, Pa. Parkersburg, W. Va. Gloucester, Mass.



by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Houston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles Seattle, Wash.

Correct Method of Applying Clips To Wire Rope

PETROLEUM ENGINEER Exclusive Feature

☆ Careful attention to application minimizes equipment replacement and machine shutdowns

by F. L. Spangler
Mechanical Engineer

THE clip fastening shown in the accompanying photograph (Fig. 1) is materially weakened because of the method of applying the clips to the wire rope. Unfortunately, it is no worse than hundreds of other clip fastenings made by rope handlers who are either careless or just don't know any better. During the present emergency when replacements of wire rope or other equipment are hard to get, and machine shutdowns are more costly than ever before, clips are highly important.

What's wrong with the application?

1. The clips are staggered instead of all being applied with the base, or saddle, against the pulling rope and the U-bolt against the short end.

2. The short end between the two top clips is slack and cannot take any of the load; hence, the top clip is useless, and we have the equivalent of only a three-clip fastening.

3. The bolts on the top clip have obviously been drawn too tight, thereby mis-shaping and weakening the rope at this point, and still further reducing the efficiency of the fastening.

4. The two middle clips are too close together. Clips should be evenly spaced at about six times or more the rope diameter.

Clips should not be drawn up too tight against the rope, but neither should they be permitted to become loose. With the clips fastened, all nuts should again be tightened after the rope has been put under tension. Clips should be tightened with every rope inspection.

When inspecting clip fastenings, it is extremely important to examine the rope at the last clip farthest from the loop or bight, as fatigue breaks often develop at this point due to the fact that rope vibration or whipping is dampened here. Fatigue damage is less pronounced with preformed wire rope, and may be explained by the reduced tendency of preformed rope to vibrate or "whip", this type of rope being more flexible and not so "springy" as non-preformed.

TABLE I

Rope diameter, in.	*Number of clips*	*Spacing of clips, in.*	*Length of wrench, in.*
½ to ⅝	3	3	12
¾ to ⅞	4	4½	18
1 to 1⅛	4	6	24
1¼ to 1⅜	4	7	24
1½ to larger	5 to 7	10	24

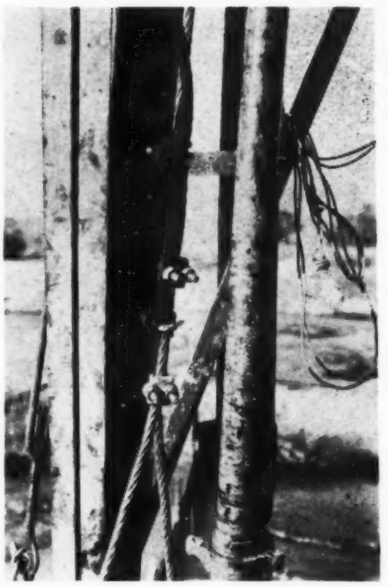
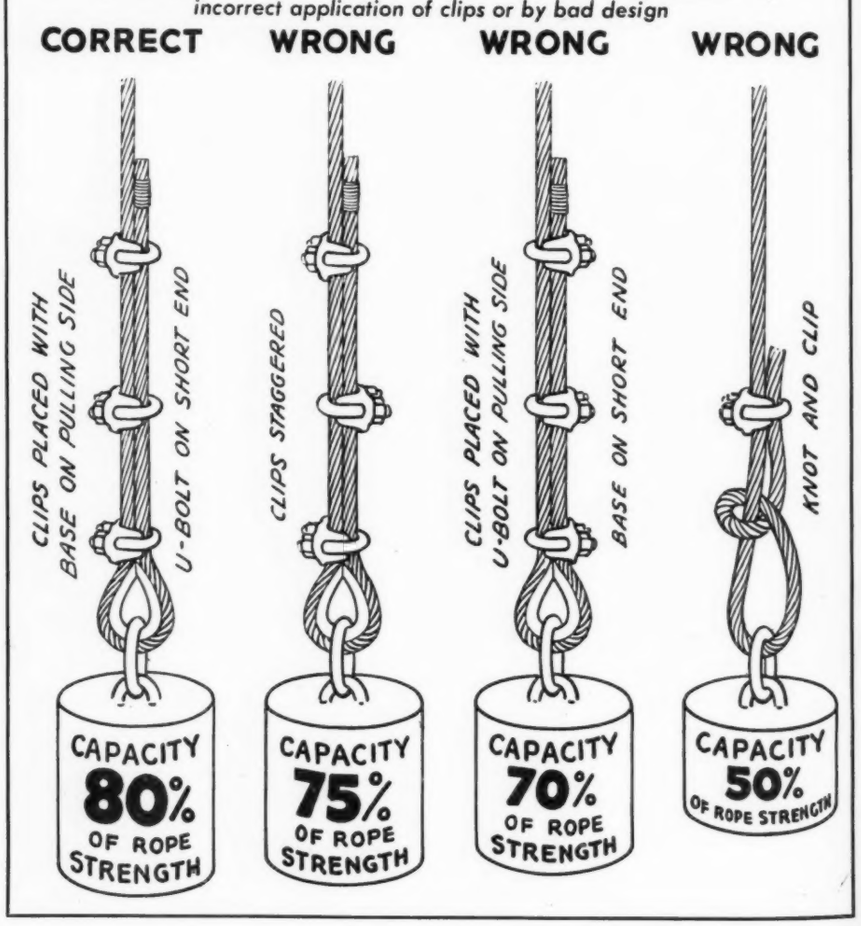


Fig. 1. Clip fastening is weakened by this method of applying clips to wire rope

It is important to apply a sufficient number of clips, and the minimum number recommended for different sizes of rope as shown in Table 1.

☆ ☆ ☆

Fig. 2. Illustrating reduced efficiency of clip fastenings caused by incorrect application of clips or by bad design


CORRECT
WRONG
WRONG
WRONG
CLIPS PLACED WITH BASE ON PULLING SIDE U-BOLT ON SHORT END
CLIPS STAGGERED
CLIPS PLACED WITH U-BOLT ON PULLING SIDE BASE ON SHORT END
KNOT AND CLIP
CAPACITY 80% OF ROPE STRENGTH
CAPACITY 75% OF ROPE STRENGTH
CAPACITY 70% OF ROPE STRENGTH
CAPACITY 50% OF ROPE STRENGTH

100-Octane Aviation Gasoline Processes Show Rapid Advance

☆ **Petroleum industry laboratories' constant research on super gasolines is important factor in design of today's modern aircraft power plant**

Exclusive

PART 1

by C. C. Pryor
Associate Editor

THE tremendous progress in the development of aircraft engines to the modern power plant of today's airplane is due largely to the availability of high-octane fuels—fuels that have been created in the laboratories of the oil industry by intensive research. Octane is defined as any of a group of eight carbon atom isomeric hydrocarbons of the paraffin series. The term "octane rating" is an arbitrary rating of a fuel that indicates its anti-knock qualities relative to an arbitrary standard. As the octane rating of a gasoline is increased, the power it will deliver is increased, and it may be used with a greater efficiency.

One-hundred octane aviation gasoline is regarded as a synthetic fuel because it is actually a combination of products consisting of a base stock, or regular gasoline, to which is added a chemical blending agent to raise the octane rating with additions of tetraethyl lead for a still further octane number increase. Base stock for this super fuel is made from carefully selected crude oils as certain of them are better adapted than others. Best aviation crude oils come from the Gulf Coast and California. There are some in Venezuela, Peru, and Russia.

First Aviation Fuels

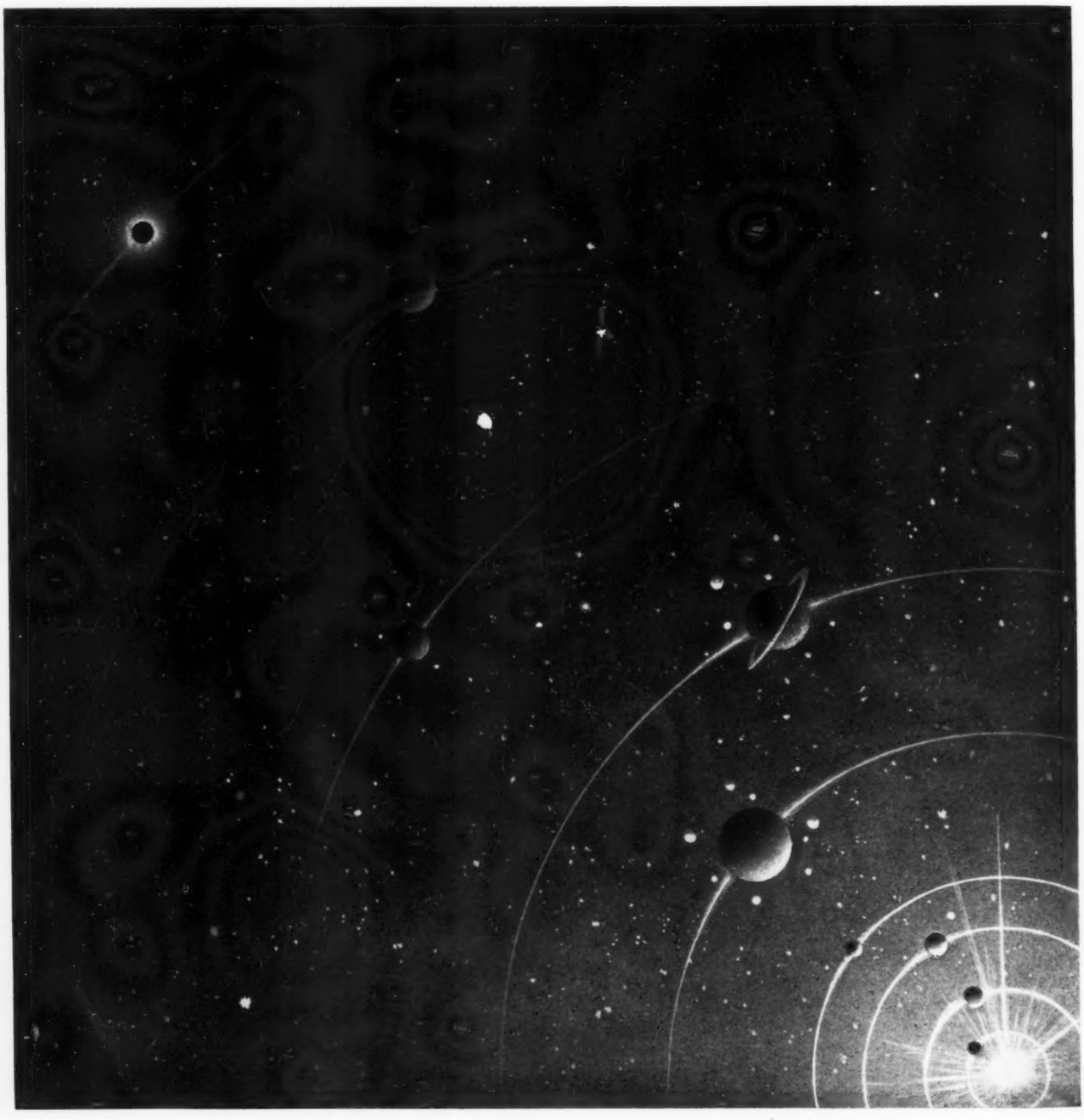
Quantity was the problem, rather than the quality of aviation fuels and lubricants for planes in 1914-18. The most generally used lubricant for warplanes was castor oil, whereas aviation gasoline was the product of straight-run distillation refining—just gasoline. Few of the engines in these planes, the air-cooled rotaries, the vertical inlines, and the V-types, were capable of developing more than 150 hp.; however, before the Armistice was signed, design engineers had increased the horsepower output to permit four-engined ships to attain speeds greater than 150 miles per hour with a ceiling of 20,000 ft.

Some 10 years later the aviation and petroleum industries began to awaken to the possibilities of higher octane gasolines. Aviation gasoline from straight-run distillation methods had proved inadequate to supply a mounting demand. Gasoline with a 73-octane rating was developed and for a brief period was a standard aviation gasoline. The addition of tetraethyl lead plus a slightly higher octane number gasoline resulted in 80- and 87-octane fuel and the petroleum industry had made the first definite step toward 100-octane and higher aviation gasoline. Addition of tetraethyl lead to raise the octane number and the ability of the refining industry to produce high octane fuels hit a ceiling at 90-octane, however, and it became obvious that new methods must be found.

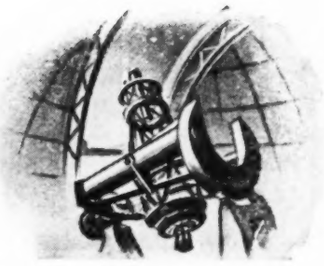
(Continued on Page 64)

Parts of a modern aircraft engine that have just undergone severe tests in a midwest plant are spread out for minute inspection. After checkup the engine will be reassembled and sent on for final inspection. Official OWI photo by Palmer

Is Pluto the Last



of the Planets?



Nobody knows. . . . It is dangerous to predict a limit in any field of research or science. The very mysteries of space—substance—energy—life—are forever quickening the human impulse to new explorations. . . . And yielding new discoveries!

TAKE the energy we call *power*. Successively through its journey out of darkness, the world has seen power wrung from the muscles of man and beasts of burden—from winds and from waterfalls—from steam, electricity and chemistry.

Momentous are the developments in the chemistry of petroleum. Even when it seemed that we had reached the last of its contributions to power which could be harnessed to do man's bidding, new reactions and refinements have been perfected to heighten the usefulness of petroleum's God-given elements.

Badger engineering is in the thick of this progress—designing, building, improving and speeding equipment for the processing of both old and new products of the petroleum industry. Toward more power for planes, trucks, tanks and other war machinery, Badger is currently constructing large and small plants for the production of high-octane gasoline.

Also in Badger's capable hands is the building of plants for the manufacture of butadiene, toluol, alcohols, explosives, acetic acid, phthalic anhydride and other chemical products.

From these stores of experience are coming still greater Badger facilities for helping industries to fight the battles of competition in the readjustment era which lies ahead.

LICENSING AGENTS FOR THE HOUDRY CATALYTIC CRACKING PROCESSES

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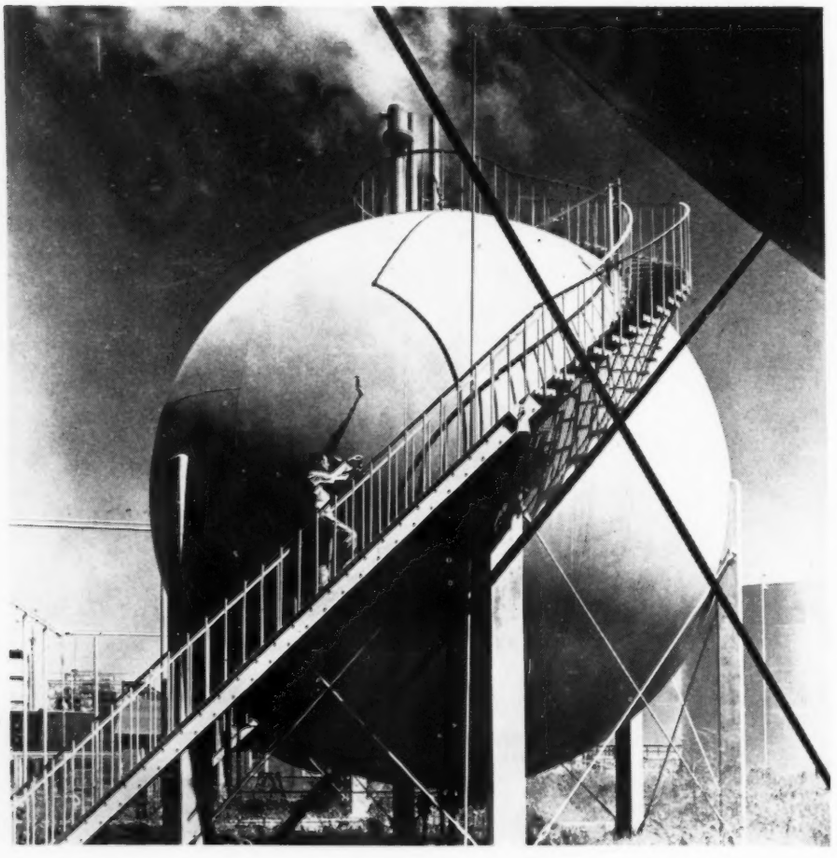
NEW YORK PHILADELPHIA SAN FRANCISCO LONDON

Process Engineers and Constructors for the Petroleum, Petro-Chemical and Chemical Industries

Technologist studying recording instruments in test room of 100-octane gasoline performance under high altitude conditions

Highly volatile products that must be mixed during the final steps in manufacture of 100-octane gasoline are stored in containers such as shown here



(Continued from Page 61)

Today the American Army, Navy, and Marine airplanes in combat are using a super aviation fuel that permits their engines to give them greater power, greatly increased fuel economy, quicker take-offs with heavier loads, and longer distance flying and heavier bombing than would be possible without the benefits of the modern chemical engineering research product—100-octane aviation gasoline.

An engine will use 20 percent less gasoline when burning 100-octane instead of 87-octane gasoline. A bomber using 100-octane gasoline instead of 87-octane gasoline receives approximately 25 percent additional power or about 300 miles greater flying distance, or it can carry an additional 5000 lb. of bombs.

Laboratory Developments

American petroleum laboratories have the reputation of sticking to the job and producing the material for which they are called upon. Scientists long had been interested in the potentialities of high octane aviation gasoline. In 1928, technologists of the Standard Oil Company of New Jersey produced 1000 gal. of crude *iso*butylene, which was purified and made into synthetic *iso*-octane, then believed a perfect anti-knock fuel, to be blended with aviation gasoline with a higher octane rating goal. By 1934 the United States Army Air Corps had carried out what were probably the first full-scale experiments on the use of pure *iso*octane, which during that time cost from $16 to $25 per gal. In their experiments, 1000 gal. of commercial *iso*octane was blended with an equal amount of the high octane rating aviation gasoline and tetraethyl lead to 2000 gal. of 100-octane number aviation gasoline. What this then "super-fuel" permitted a plane to perform was indicated by the Army Air Corps almost immediately issuing its first specifications covering the fuel. In early 1935, its first order called for 100,000 gal. and in June of the same year it asked for bids on an order for 1,000,000 gal. Fuel for pursuit aircraft was standardized on 100-octane gasoline by 1937. The fiscal year of 1939 saw army purchases of 30,000,000 gal.; a purchase that was doubled in 1940.

Photographs, unless otherwise credited, are by Robert Yarnall Richie. The photographs by Richie and much of the material of the article by courtesy of Standard Oil Company of New Jersey.

EDITOR'S NOTE: This article will be continued in an early issue.

☆ ☆ ☆

SQUEEZE 'EM WITH 'STARCOR'

TO STEP UP production from existing wells and conserve pumping and other equipment, many Operators are pushing ahead with reconditioning programs. Outstanding performance on hundreds of squeezes and workovers, makes 'Starcor' Oil-Well Cement the number one choice. Well after well, making 60% salt water — squeezed with 'Starcor' — now makes pipeline oil. Use 'Starcor' for consistently successful down-the-well results.

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Geophysical Activities in California

PETROLEUM ENGINEER Exclusive Feature

☆ **Recent work has given increased consideration to small features at greater depths and to the finding of stratigraphic traps**

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

THE territory in which geophysical prospecting is being conducted is somewhat of an index of exploratory activity in California. Although this does not mean that wildcat wells are not being located and drilled on the basis of data obtained by earlier geophysical surveys and geological information, the interest in a general area is manifest by the number of geophysical crews at work in that area. At the present time most of the geophysical activity of the state is in and around the Sacramento Valley. Although no oil of any consequence has yet been discovered in that area, there have been gas discoveries. Further drilling may discover oil but gas itself is now an important commodity, particularly in that region where it is more or less readily accessible to the San Francisco Bay industrial area.

Most of the geophysical prospecting in the state is by use of the reflection seismograph method, although five gravity meter crews are also active in the Sacramento Valley at the present time. Practically all the major oil companies employ geophysical prospecting in their search for oil and gas in all parts of the state and a great many of the discoveries during the last few years were based on geophysical data. Although geophysics has been employed extensively in the Los Angeles Basin and in the Santa Maria, Ventura, and Sacramento valleys, the greatest amount of reflection seismic work has been done in the San Joaquin Valley.

Early geophysical prospecting in the San Joaquin Valley considered mainly the big features of the subsurface formations; and structures with plenty of closure were sought. With such objectives in mind only loose control was necessary. Later the geophysical work considered smaller features but with depths limited to 7000 to 8000 ft. After this, more attention was paid to deeper features and depths became as great as 10,000 to 11,000 ft. With the most promising area of the Valley thus covered by the control necessary to pick up small features and reach depths of more than 10,000 ft., geophysical prospecting now must consider very small features at great depth and must locate stratigraphic traps. Moreover, complicated fault structures that heretofore have not been solved by geophysics may be determined in the future by seismic exploration. The continuous profiling method is necessary in practically all cases in this present phase, which is still to be completed.

To accomplish this latest phase of geophysical prospecting in the San Joaquin Valley, very careful interpretation is necessary; and even with the great care being exercised the resulting map frequently is not as complete in detail as the ordinary geophysical map. Geophysical prospecting in this area is probably being stretched more than in any other place in the United States and is being made to go as far as possible in order to locate smaller as well as the more complex structural features.

During the last two or three years, greater attention has consequently been given to the smaller structures in the San Joaquin Valley; so reflection seismic work has been more highly concentrated in areas that the more widely-spaced previous shots had indicated as most promising. This is illustrated by the area southwest of Fresno where the more recent discoveries such as the Raisin City, Helm, and Riverdale fields resulted. Closer spacing of shot lines and of shot points on those lines has already been done in a number of other areas and wildcat wells are being drilled on highs disclosed by the more closely controlled geophysical surveys. Other areas, both in the San Joaquin Valley and in other territories, will probably be reexplored by geophysical crews, and although many of the structures to be located by closer spacing of shots will probably be limited in areal extent, they should aid materially in maintaining the oil reserve of the state.

This type of work is very costly and will in all probability result in a higher ratio of dry holes per discovery. Further closer control, however, will undoubtedly be utilized in geophysical prospecting for smaller structures and deeper zones in many of the more prospective areas in the state; but economic considerations will probably have a definite influence on the time and extent of such exploratory endeavors.

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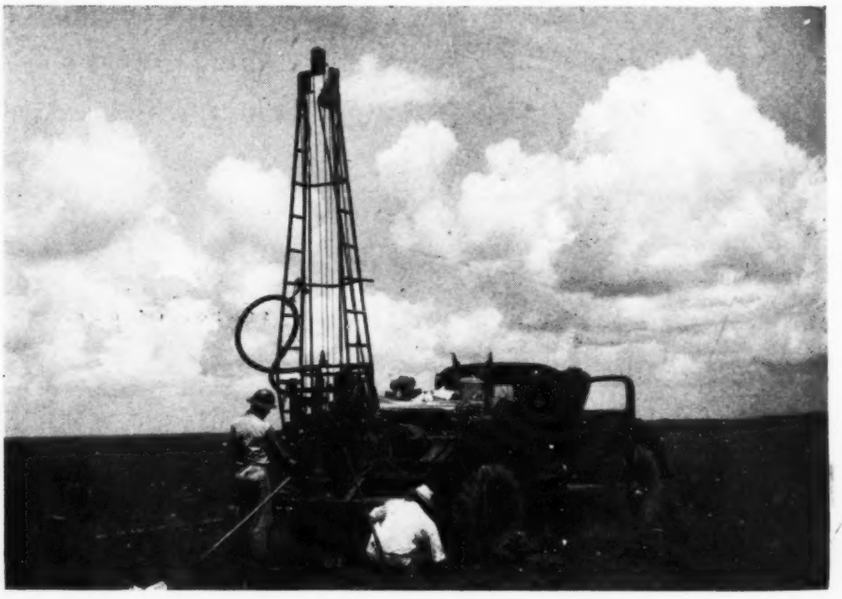
Drilling a shot hole for seismograph exploration in San Joaquin Valley, California
(Photo courtesy Western Geophysical Company)



Proper Maintenance Prolongs Instrument Life

PETROLEUM ENGINEER

Feature

☆ Maintenance methods must be supplemented by careful study of manufacturer's instructions for use of instrument

by Theodore A. Cohen

Vice-President and Chief Engineer, Wheelco Instruments Company

IN recent years, instruments have found many and unusual applications in all industries. They are being applied to reduce labor costs in manufacturing processes, lower fuel costs through exact control, speed production, and improve quality and eliminate spoilage or rejects.

Continued enjoyment of these benefits is dependent, to great extent, upon proper care of instruments now installed, whether they are doing 24-hour service in defense industries, or normal service in non-defense plants. Shortages of critical materials are necessitating substitutions in components of many instruments, and heavy demand upon manufacturers is slowing delivery of certain types regardless of the priority held by the purchaser. Needs of defense industries make delivery of instruments impossible to many other companies.

Methods that can be employed to prolong the life in industrial instruments, regardless of manufacture, are outlined in this article. This information should be supplemented by careful study of instructions supplied by the manufacturer of each instrument to make sure the equipment is installed and operated according to the manufacturer's recommendations. If such instructions have been mislaid or lost, model and serial numbers of the instrument should be sent to the manufacturer with a request for new instructions.

Centralize Responsibility

One man, or a group of men, depending upon the number of instruments used, should be responsible for all instruments in a plant. Responsibility for instrument care and maintenance should not be left to the men operating the equipment on which they are installed, as such practice will result in complete lack of maintenance, or in unnecessary or harmful handling by individuals unfamiliar with instrument operation.

Proper Placing

Improper placing and installation of industrial instruments probably cause more trouble and inaccuracy than fault or failure in the instruments themselves. It is as important that instruments be installed where they can be properly serviced and protected as it is to install them where the bulb, thermocouple, photoelectric cell, radiation head, or other "sensing" unit can reach the temperature, pressure, vacuum, or other condition the instrument is to measure.

THEODORE A. COHEN

was born in St. Louis, Missouri, September 3, 1908—He obtained his secondary and preparatory schooling in Chicago and entered Rochester Polytechnic Institute in 1927, later taking courses at Massachusetts Institute of Technology, Columbia University, and Troy University while acting as an engineering consultant for such companies as Eastman Kodak Corporation, De Forest Radio Corporation, Bell Telephone Laboratories, Federal Radio Corporation, and others—He holds degrees A.B., E.E., B.Sc., M.Sc. —Following completion of formal training he returned to Chicago, becoming consulting engineer for a number of electrical, radio, and transformer manufacturing companies—In 1931 he served as chief engineer for Federal Radio Corporation, later serving in same capacity for Meissner Manufacturing Company and Dramaphone Division of Excelsior Motor Manufacturing Company—In 1935 the Wheelco Vacuum Products Company was founded for the manufacture of special devices developed by him, which later became the Wheelco Instruments Company—He was commissioned a Second Lieutenant Coast Artillery Anti-Aircraft in 1932 and a First Lieutenant 1937—Membership in engineering and technical societies include the Institute of Radio Engineers, Western Society of Engineers, American Society of Military Engineers, Chicago Physics Society, and American Institute Electrical Engineers.

Eliminate Vibration

Prolonged vibration and shock resulting from careless handling are chief causes of instrument failure. Installing instruments on vibration mounts will minimize the effects of vibration. A better method is to mount instruments in locations where vibration is not present. Instruments should not be mounted upon furnaces or moving machinery. If instrument panels also carry contactors, these contactors should be removed so that the shock to the instruments resulting from operation of the contactors is avoided.

Pivots and bearings, particularly of pyrometric instruments, will cause trouble from misalignment or deterioration if the instrument is subjected to sudden shock or persistent vibration. A sudden jar or jolt may crack a jewel bearing, or cause the pivot to jump out of its bearing, and repeated vibration will dull pivots and reduce an instrument's sensitivity.

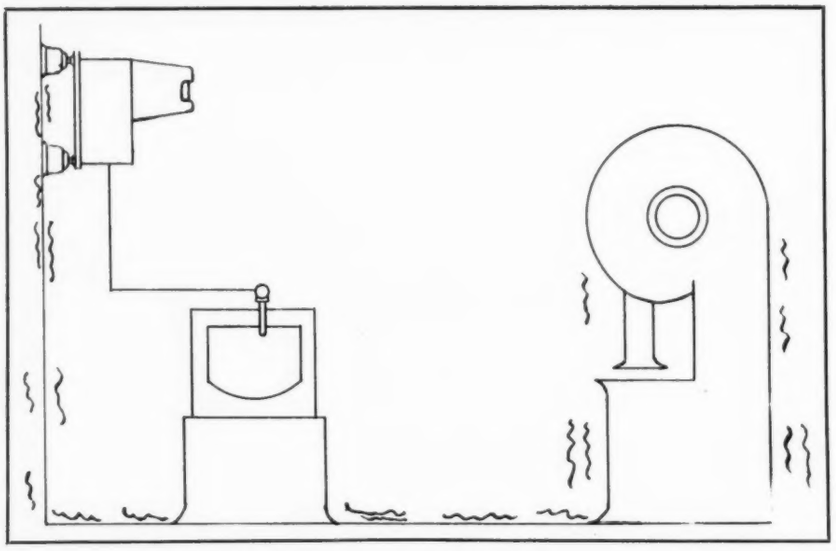
Protect From Dirt

Next to excessive vibration, infiltration of dirt probably causes most industrial instrument trouble. When instrument movements are particularly sensitive to foreign material that might affect their operation, they usually are provided with dustproof cases. Such instruments should be opened as infrequently as possible, and then preferably in the instrument shop or in a room where provision can be made to keep parts clean. The slightest particle of dust or lint caught in the air gap of a millivoltmeter pyrometer, for example, can obstruct the free movement of the coil, whereas a metallic particle adhering to the pole pieces of the permanent magnet can completely stop functioning of the instrument.

Avoid Excessive Temperatures

For best results, excessive temperature, both high and low, must be avoided at the point where the instrument is installed. An instrument is built to give best operation at room temperature, approximately 70°F., and prolonged use at extreme temperatures will affect the instrument's accuracy.

All instruments are subject to error in measurement if exposed to large changes in room temperature, as exact



Rubber mounts will dampen instrument vibration induced by machinery or equipment in the plant

compensation for such changes, over large ranges, is uncommon. It is best to mount instruments in locations where minimum temperature changes will occur at the instrument. Instruments should not be subjected to ambient temperature changes larger than 80°F.; for example, from 40 to 120°F. It is preferable, however, to keep the temperature at the instrument as close as possible to 70°F.

Corrosion Hazards

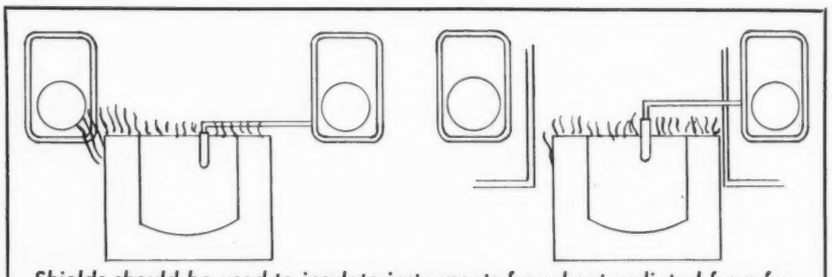
An instrument, regardless of its function, will be impaired if placed in a corrosive atmosphere. Corrosive fumes attack instrument finish, moving parts, measuring systems, and may directly result in measuring error and impaired or erratic performance. Special corrosion-proof cases are available for most instruments, but even these do not give absolute protection when the necessity of opening case doors for chart changes on recording instruments and adjustments to other instruments is considered. A small compressed air line connected to the case, with an escape provided through a small breather hole in the case, will properly ventilate the case and provide a slightly excess pressure within it to keep out room atmosphere at all times.

Corrosive fumes will also attack bulbs, bulb sockets, connecting tubes between bulbs and instruments, thermocouples, and lead wire. Painting bulbs and bulb sockets with corrosion-resistant paint will prolong their life. A badly corroded bulb socket should be replaced to prevent its complete failure and resultant damage to the bulb.

Tubing and Lead Wires

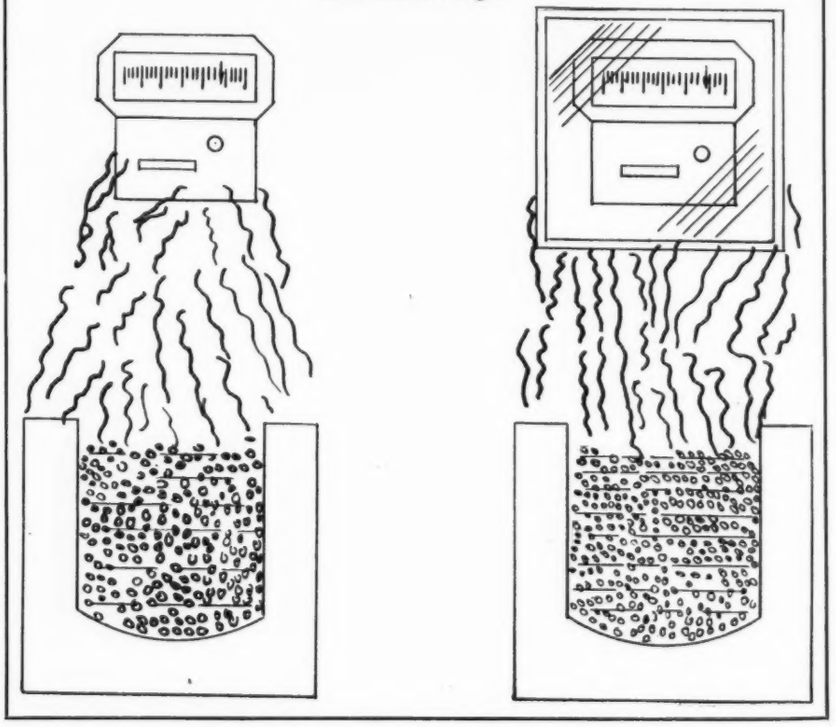
If protection tubing for capillaries of filled-system instruments is damaged, wind with tape to prevent further deterioration. Carefully remove any sharp kinks in the tubing. If tubing or lead wires run near the floor, build a housing over them or fasten them securely to some solid object where they will not interfere with, or be disturbed by, passing traffic. In the absence of metal conduits for protecting capillary tubing between bulb and instrument, wooden strips can be employed to give the same protection.

Lead wires from thermocouples of pyrometers, or sensing elements of other instruments, should be so placed they will not be snagged by workmen, passing trucks, or cranes. Examine insulation regularly, and take steps to prevent its abrasion. Worn or cracked insulation can be taped, and connections



Shields should be used to insulate instruments from heat radiated from furnaces, ovens or processing equipment. Accuracy of the instruments at the left will be affected by heat radiated from the equipment, whereas those shown schematically at the right have been given protection

Instruments in corrosive atmospheres should be protected by vapor-tight cases. The instrument at the left will give poor performance and have short life as compared to the instrument protected against corrosive fumes at the right



To Cool The Axis

☆ **COOLING TOWERS** are an important part of the silent service operating behind the lines. The operation of the most perfect mechanical equipment in the world *can only be as good as the auxiliary equipment which serves it.*

The fact that Water Cooling Equipment Corporation Cooling Towers are serving the Air Corps, The Army, The Navy and the great production plants of the country, is ample evidence of their absolute dependability under the most exacting conditions.

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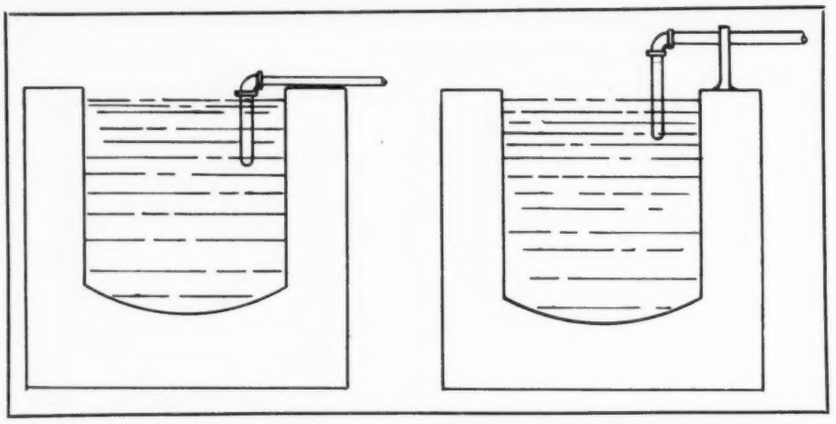


Incorrect and correct installation of an instrument "sensing" unit. Immersion of the unit at the left in the fluid to the point of the right-angle junction provides conditions conducive to excessive corrosion. Proper installation is shown at the right

should be checked to make sure they are tight. Locate lead wires away from flames, hot gases, hot pipes, and water or oil drips.

Avoid Excessive Moisture

Excessive moisture will often harm industrial instruments. A protective case is recommended for installations where moisture cannot be avoided.

Do not expose instruments to strong magnetic fields.

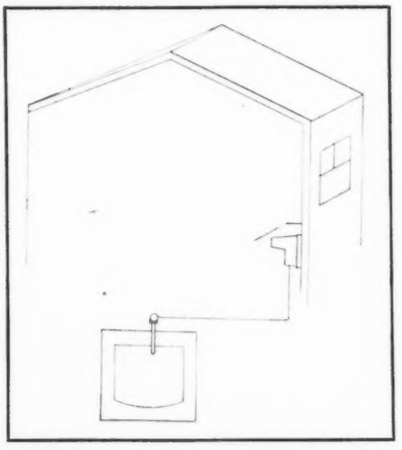
When installing or relocating instruments, make sure all connections have been made exactly as specified in the instructions. All connections must be tight and free from dirt and moisture. Clean contacts and terminals often.

Charts for recording instruments should be stored in a cool dry place. Keep charts flat, preferably in their original package, until used. When recording instruments are out of service for any length of time, shut off power to the instrument and remove ink from the pens.

Pressure Instruments

Pressure instruments frequently require special attention, as their vital measuring elements usually are exposed to the material undergoing pressure treatment. This material ordinarily fills the measuring system, and may cause trouble if the installation is not properly made.

The material being processed may seriously corrode the element, may solidify in the measuring system at the ambient temperature, or it may deposit heavy tars that would clog the measuring element. Protection from these conditions may be obtained by use of a diaphragm seal mounted below the gauge, with the bourdon tube of the instrument and upper diaphragm housing filled with glycerin and oil.



A shield over an instrument, particularly when installed near a window that may be open from time to time, will provide protection against moisture that may enter the window during a rain

Fluid Pulsation Protection

Fluid pulsation is another cause of inaccuracy and short life of pressure instruments. A rapidly pulsating pressure will destroy the accuracy of the delicate sector-and-pinion movement by wearing the gauge teeth and bearings. A shut-off valve placed ahead of the gauge, and throttled until the pulsation disappears, will overcome this condition, but may result in clogging of this very small opening. Gauge snubbers have been introduced to provide the same result. One type employs a large number of small passageways with changes in direction; in another the inertia of a moving piston prevents rapid pulsation; a third type employs a rubber diaphragm with the gauge tube filled with glycerin, the latter throttled by passing through a felt retainer.

Over-Range Protection

Be sure that the instrument has ample over-range protection to prevent blowout at any pressure likely to be applied to the equipment or line. It is good practice to allow a margin of 100 percent more range than necessary to measure normal operation pressures for the equipment.

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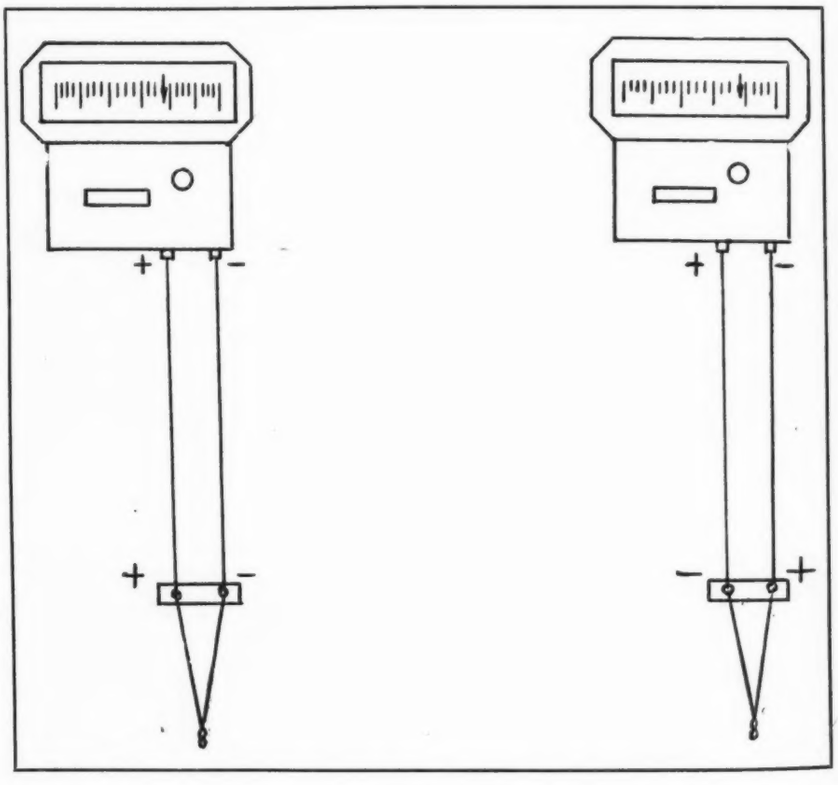
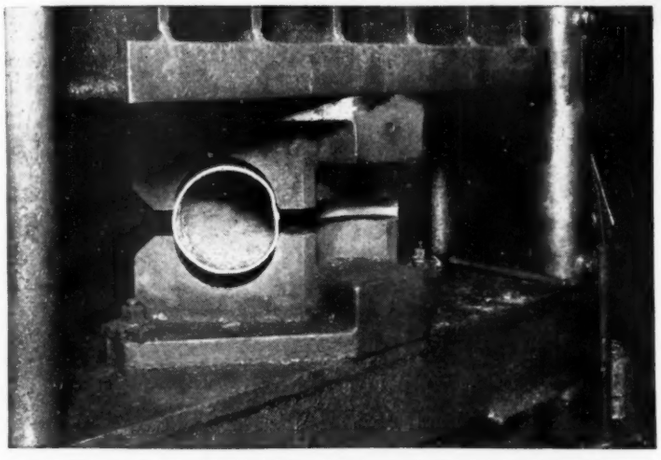


Lead wires of the instrument at the left are incorrect as to polarity. Proper wiring is shown at the right

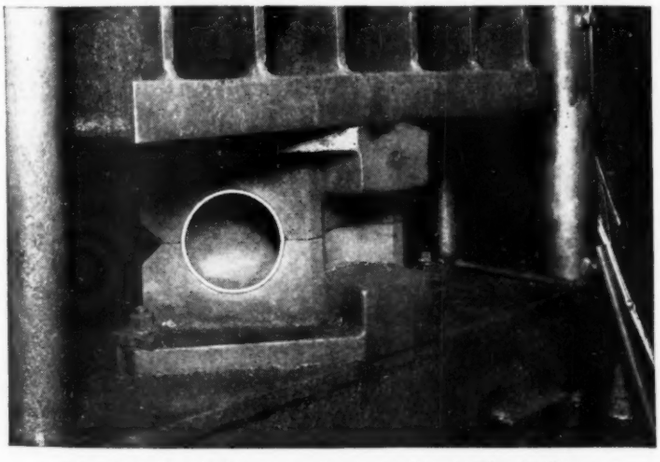
MIDWEST

BUTT-WELDING ELBOWS

Have Greater Dimensional Accuracy and Uniformity



(Above) Oversize Midwest Elbow has been reheated and placed in sizing die for reduction to exact size and shape. Dies have just started to compress 8" elbow having circumference ½" greater than when finished.



Showing the sizing operation completed. The Midwest Welding Elbow now has true circular cross section, uniform wall thickness, and accurate radius, included arc and tangents.

They are SIZED IN COMPRESSION

This exclusive Midwest feature is very important to all users of welding elbows because it (1) saves time (and therefore money) in lining up pipe and elbow, (2) saves welding time, and (3) assures more uniform welds.

This feature results from the unique process for manufacturing Midwest Welding Elbows. The Midwest Elbow is first made slightly oversize . . . it is then reheated and reduced to accurate size and shape by a final working of the metal in *compression* at a forging heat—it is not extruded or stretched.

This feature applies to all Midwest Welding Elbows—both American Standard and "Long Tangent." See Bulletin WF-41 for details regarding the many other advantages of Midwest Welding Fittings.

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MIDWEST WELDING FITTINGS SAVE TIME, IMPROVE THE DESIGN, AND REDUCE THE COST OF PIPING SYSTEMS

Multiple Batch Squeeze Cementing

☆ Efficient supervision in foreign field involves series of gauge tank measurements

by S. P. King

Petroleum Engineer, Trinidad Leaseholds, Ltd.

S. P. KING

received a B.E. degree in petroleum engineering from the University of Southern California in June, 1941—At various times previously, mostly during summer vacations, he had worked for the Wilshire Oil Company, Norwalk, California; Royalite Oil Company, Turner Valley field, Alberta, Canada, and Lane-Wells Company in the Turner Valley field and western Canada wildcat areas—Upon completion of his university work he joined the staff of Dowell Incorporated at Turner Valley, later relinquishing that post to accept his present position as petroleum engineer with Trinidad Leaseholds, Ltd., Forest Reserve, British West Indies.

MULTIPLE batch squeeze cementing jobs can be more efficiently supervised by utilizing brief forms that convert the entire job into a series of gauge tank measurements. This technique has been found especially adaptable by the writer in foreign fields where very often native labor and the lack of modern cementing equipment and trained personnel augment the petroleum engineer's responsibility on the job. Many improvised cementing units consisting of pumps, slurry tanks, and mixing hopper mounted on truck or trailer, if properly handled, can function very efficiently. The usual lack of flexibility in pumping, inability to achieve any adequate mechanical control over mixing speed or slurry weight plus the not infrequent unavailability of a particular type of cement for a specific purpose tend to complicate a straightforward cement job. Under these circumstances, it is to the engineer's advantage to organize his work to provide a maximum allowance for any eventualities requiring his personal supervision.

The technique can perhaps be best illustrated and more readily understood by applying it to a specific squeeze job. A 2500-ft. well required a shut-off of bottom water believed coming into the producing interval 2000 to 2150 ft. from a wet sand 2300 to 2350 ft. The well was killed with mud, gun-perforated at 2300 ft. with four ½-in. holes, and a cement retainer set at 2290 ft. The cementing unit is spotted at the well, the conventional hook-ups made, and the fittings tested to 3000 lb. per sq. in.

Procedure

The engineer meanwhile is compiling his forms and planning the job. Maximum surface squeeze pressure (40 percent of depth of the horizon to be squeezed plus 1000 lb. per sq. in.) is computed at 1920 lb. per sq. in. From past experience, the size of each batch is set at 25 sacks, and the interval between batches at 4 hours. Because the formation is quite permeable and channeling of the original cement job is believed to be the reason the productive sand is cutting water, a slurry approximately 116 lb. per cu. ft. is chosen to ensure cement being deposited in the channels and uniformly plastered on the face of the sand. Anticipating possible difficulty in achieving progressively higher pressures with each batch because of the channeling, 100 lb. of bentonite are sent to the well for the preparation of gel cement should the latter be deemed necessary. From this point, the job resolves into two stages: first, the placing of consecutive batches of 25 sacks through the retainer at a final surface squeeze pressure of less than 1920 lb. per sq. in. cleaning the retainer and shot holes for successive batches, and second, the placing of the final batch achieving the final surface squeeze pressure with the pumps stopped, and cementing the retainer in the hole.

Calculations

Each stage is converted into a series of measurements enabling the engineer to supervise the entire job from the slurry tank. The following symbols are used to formulate the technique:

S = the number of sacks of cement used,

Fig. 1

Well Total depth 2500 ft. Plugged back 2372 ft.
Casing, 6⅝-in. 20-lb. 0 to 1900 ft.; 28-lb. 1900 to 2500 ft.
Perforations, 2000 ft. to 2150 ft.; 2380 ft. to 2410 ft. plugged back.
Remarks
Breakdown pressure with water: initial 870 steady, minimum 610 lb. per sq. in.

With circulating joint open, pump	Gauge tank in.
1. 4 cu. ft. of water	2
2. W + 0.51 S cu. ft. of slurry 18 + 0.51 × 25 = 30.75	9
3. 2 cu. ft. of water	1
4. Tubing volume — (1) — (2) — (3) + casing flag 2290 × 0.0217 — 4 — 30.75 — 2 + 2 = 14.75	7½ (—) mud
With circulating joint closed, pump	
a. (1) + (2) + (3) — casing flag 4 + 30.75 + 2 — 2 = 34.75	17½ (—) mud
or	
b. (1) + (2) — cu. ft. of cement to be left above retainer — casing flag 4 + 30.75 — 2 — 2 = 30.75	15½ (—) mud

Pressure volume data

1st squeeze: 500, 650, 680, slowed pump down, 660, 580, 560, 370, 365, 440, 600, 720, 860, 970, 1050, 1080, 1050, cement through shot holes, 1010 ft., shot holes cleared 25 sacks away.
2nd squeeze: 870, 900, 920, slowed pump down, 790, 450, 390, 560, 710, 820, 1000, 1120, 1210, 1210, 1220, 1240, 1160, cement through shot holes, 1150, 25 sacks away, 1140.
3rd squeeze: 1010, 1030, slowed pump down, 410, 360, 300, 600, 760, 1100, 1310, 1500, 1510, 1540, 1520, 1520, 1520, 1460, cement through shot holes 1450, 25 sacks away.
4th squeeze: 1320, 1360, slowed pump down, 610, 540, 920, 1210, 1340, 1420, 1610, 1880, 2080, stopped pumps, final squeeze 1995 lb. per sq. in.
Back washed 2 cu. ft. cement (approx.) recovered casing flag.
N. B.—25 lb. of bentonite mixed with water used in slurry of third squeeze.

Official U. S. Navy Photograph

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BUY WAR SAVINGS BONDS to help arm, clothe, feed, and transport our boys so that they will have every advantage in their encounter with the most vicious adversaries in the history of warfare.

Consider the cost if we lose the war. Slavery, hunger, degradation would be ours as it is the lot of other nations which only wanted to be let alone to work out their separate destinies.

In addition to insuring liberty and the good things which our way of life has made possible far beyond the fondest dreams of other peoples, your buying War Savings Bonds to the very limit of your ability gives you cash to buy the wonderful new things that will be manufactured in the after-the-war age of plastics and chemurgy. An immense purchasing reservoir built up by millions of bond buyers will help insure continued prosperity and employment after peace comes.

★ ★ ★ ★ ★ ★ ★ ★

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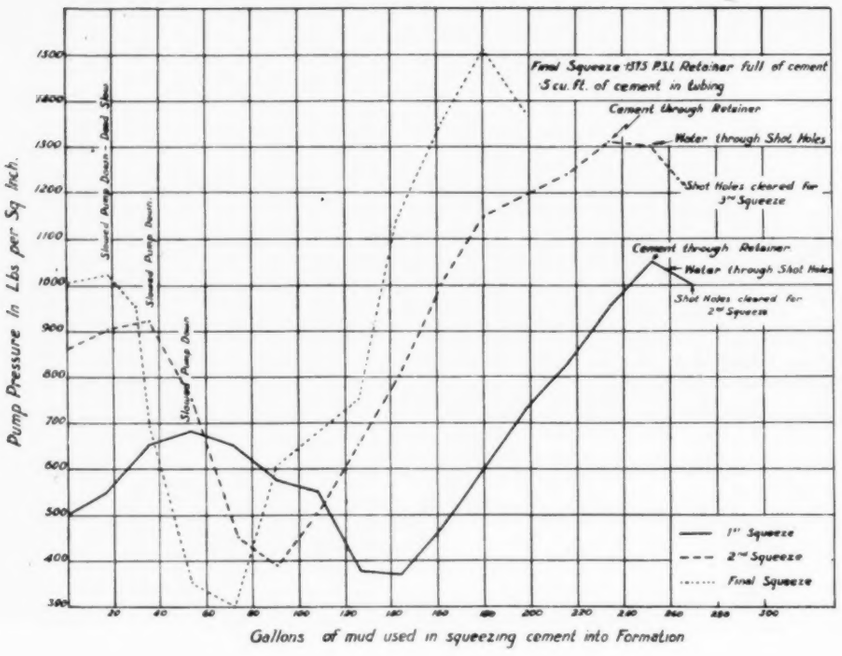
Pump Pressure in Lbs per Sq Inch.
Gallons of mud used in squeezing cement into Formation
Final Squeeze 1375 P.S.I. Retainer full of cement 3 cu. ft. of cement in tubing
Cement through Retainer
Water through Shot Holes
Shot Holes cleared for 3rd Squeeze
Cement through Retainer
Water through Shot Holes
Shot Holes cleared for 2nd Squeeze
Slowed Pump Down - Bled Slow
Slowed Pump Down
Slowed Pump Down
1st Squeeze
2nd Squeeze
Final Squeeze

Fig. 2. Pressure-volume curve of a typical squeeze cementing job

W = cu. ft. of water required to mix S sacks of cement to the desired slurry weight.

The form carried to the well by the engineer for the squeeze job in the example is composed as in Fig. 1.

The calculations with the circulating joint open, involving the spotting of the cement above the retainer, are in order: water pumped ahead of cement to prevent contamination by the mud and 2 cu. ft. (the + 2 item in (4) Fig. 1) to serve as a casing flag to indicate complete recovery of cement during backwashing operations; the cement slurry[1]; water pumped behind cement to prevent mud contamination and to indicate via fluctuation in pump pressure when the shot holes have been cleared of cement; the volume of mud required to spot the slurry on top of the retainer with 2 cu. ft. of water ahead of it, and 2 cu. ft. of water as a flag in the annulus. The volume of water pumped behind the cement should be sufficient to clear the shot holes and occupy the volume between the latter and the retainer. By spotting mud to the tops of the retainer, overbalancing is prevented when the circulating joint is opened to backwash between squeezes. If a perforated interval exists immediately above the retainer, any sharp momentary pressure fluctuation caused by overbalanced fluid columns equalizing through the opened circulating joint, if possible, should be avoided. It is always advisable to open the circulating joint and backwash the casing flag out of the tubing to prevent hardening of any cement accumulations inadvertently left either above the retainer or in the tubing.

With the circulating joint closed, the calculations are merely mud volumes to be pumped from gauge tank to put cement away and leave the retainer and shot holes clear for successive batches. The final squeeze calculation is the maximum volume that can be put away and still leave the retainer cemented in the hole. During all these operations the engineer keeps a record of the pressure at which each ½-in. or 1-in. is pumped. These data are later converted into pressure-volume curves graphically depicting the entire job. Fig. 2 is a typical graph of a squeeze job having an objective maximum squeeze of 1500 lb. per sq. in. and batches consisting of 20 sacks each.

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[1]The tank computation is 9 in. (water only) as the cement was mixed in the hopper and pumped directly to well.

P 531.

Chemical Pump Operated by Arm Clamp on Walking Beam

by J. C. Albright

WHEN pumping units are so constructed that the chemical proportioning pump cannot be attached to the base or frame and operated with a straight vertical rod, or actuating wire, the chemical unit can be placed outside the screened-in enclosure on the concrete pad around the casinghead. To obtain the necessary movement to actuate the pump to feed the chemicals into the lead line, a convenient length of pump rod or other round bar iron is employed. Instead of connecting one end of this rod to the pumping unit beam by welding or bolting direct, two small wing nut clamps have been found adequate for the fasteners. Such clamps have been plentiful at dime stores or variety hardware establishments. By using this type of arm fastener, any length stroke desired for the chemical pump can be obtained easily and quickly by simply loosening the wing nut or bolt, and sliding the actuating rod along the top of the pumping unit walking beam.

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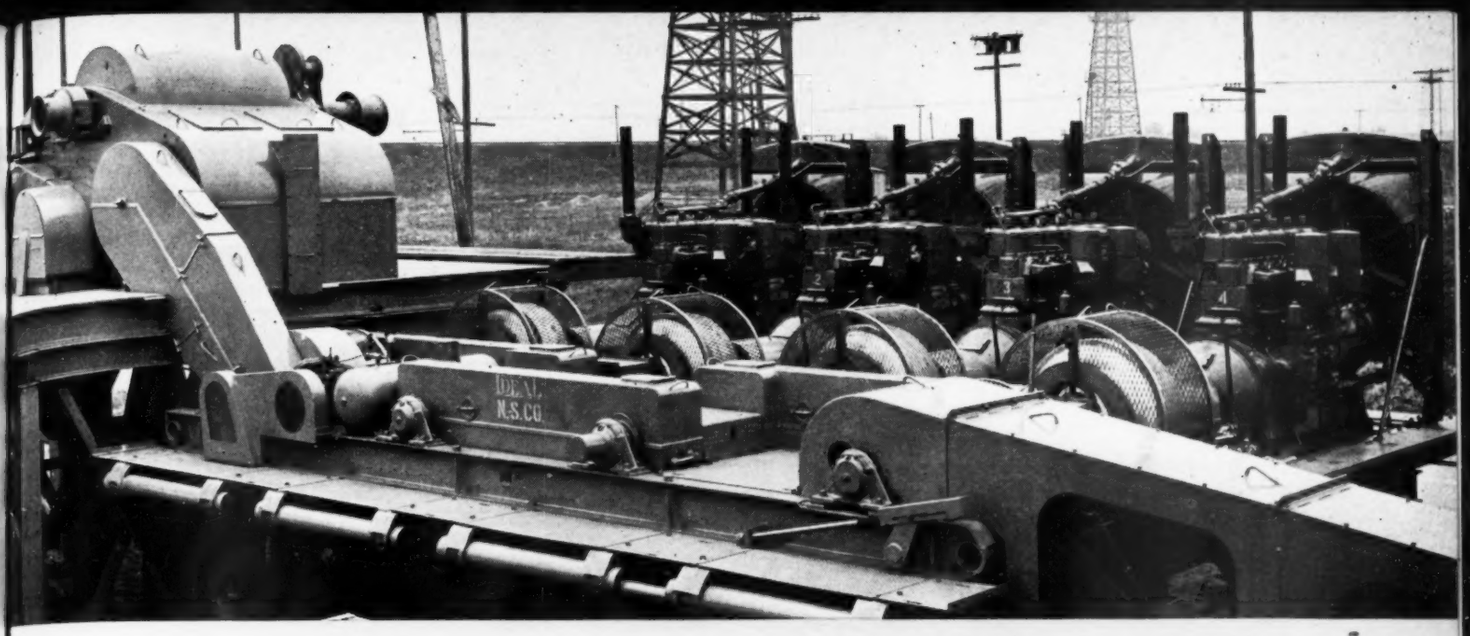
Actuating rod is attached to walking beam by wing-nut clamps



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These are most important questions under war conditions. They are questions to which you can, however, contribute much to the answers.

When we built your Ideal Consolidated Rig, we combined highest grade materials with skilled craftsmanship and long experience in the production of oil field machinery and equipment that you could be assured of a rig that would serve you long and serve you well . . . Performance records attest to the durability and the efficiency of Ideal Consolidated Rigs and of the individual units of which they are composed.

These basic and intrinsic values will, if conserved, keep your rig operating efficiently and economically beyond the customary expectancy of service.

We Recommend the Following Maintenance Schedule:

DRAW WORKS AND DRIVE GROUP:

1. Maintain adjustments of all friction clutches and replace worn out parts that impair efficient operation.
2. Keep all roller bearings properly lubricated.
3. Make frequent inspection of all positive clutches and shifter mechanisms.
4. Check air control equipment for leaks—connections, lines, valves and compressor unit.
5. Chain and V-belt drives should be systematically inspected for correct tension and alignment. Proper lubrication prolongs chain life.

ENGINES:

1. Avoid continuous overloading. It may become necessary to change to smaller pump liners as the well gets deeper.
2. Change crankcase oil at regular specified intervals and use only high quality lubricants.
3. Keep all filters clean.
4. Inspect engines frequently to detect worn or stuck piston rings, valve wear and clearances, and correct immediately.
5. Maintain proper clearances of main and connecting rod bearings at all times.

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Refinery Practice for the Operating Man

Vocational Class Proceedings in Refinery Engineering

Manufacture of Lubricating Oils

Class Meeting No. 7

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils it usually denotes an interchange of discussion among the class members themselves.

Leader: Considering the features of an ideal solvent as given by the author in the text (pages 111 and 112), we see that chlorex meets most of the requirements for a good solvent.

A solvent should have good extraction properties—chlorex produces oils having high viscosity index number. Loss of solvent by solution in oil and extract should be small. The chlorex process reports losses of about 0.04 to 0.08 percent. The solvent should show the best solvent powers at about 70°F. and should be stable under operating conditions. The chlorex process operates at a temperature from 50 to 125°F. with the solvent being recovered at about 325°F. under a vacuum of 26 to 28 inches mercury, at which temperature chlorex is stable. The specific gravity of the solvent should be high to permit easy phase separation. Chlorex has a specific gravity of 1.22. The solvent must be cheap and available. Chlorex is sold by one company at about $1.47 per gal. with the price of the solvent including all process royalties. A solvent should be non-corrosive; after being processed to neutralize hydrochloric acid, chlorex is non-corrosive.

A solvent should be non-toxic. Using customary industrial caution, chlorex is non-toxic, and is also non-explosive. With solvent-oil ratios of about 3:1 the amount of solvent necessary is not excessive. What is the viscosity of the charge?

Pupil: The viscosity is 164 S.S.U. at 100 charge.

Leader: What is the temperature of solvent recovery?

Pupil: From 300 to 325°F. with the vacuum used.

Leader: The viscosity index for refined Pennsylvania neutral oil stock was 112. A steam-refined cylinder stock gave a 4 percent loss, but a Mid-Continent stock yielded only 71 percent.

The use of bubble towers is being experimented with but at the present time wax interferes with the use of this type of equipment.

Pupil: Can you manufacture 100 viscosity index oil from Mid-Continent crude with this process?

Pupil: If you take sufficient loss you can.

Leader: Sulphur dioxide treatment is the only solvent extraction process in which oils from light naphtha to overhead stocks can be processed. It is satisfactory for lube oils by adding another solvent such as benzene or similar aromatic compound in conjunction with sulphur dioxide.

The distillate is cooled with a water cooler before it is added to the system.

The extract contains aromatics, resins and asphalts and substantially SO_2. There is a series of five evaporators of decreasing pressures having a vacuum pump on the latter one.

Very good separation is maintained in the chillers. Sulphur dioxide does not dissolve paraffin wax and further reduces the solubility of paraffin wax in the benzene. The solvent is recovered from the oil in a series of evaporators similar to recovery from extract.

This process, using a mixed base charge, will raise the viscosity index from 90 to 100. The oxidation stability is very good. It is very slow to emulsify. The carbon residue is improved and in general appears to be a very good process.

Pupil: Some chemical reaction takes place as well as physical.

Leader: There is not a great deal of difference in the yield recovery of the processes. The yields seem to be quite close when producing a comparable viscosity index, as shown in Table 7. (See page 96, February issue, *The Petroleum Engineer.*) I think a cost of 15 to 20 cents per bbl. would be about right for most of these processes. One of the big items is royalty.

Pupil: The furfural process has a counter flow treating tower that has about 20 ft. of Raschig rings arranged so they may be taken out every 4 ft. and repacked. The charge enters at the bottom of the tower and the furfural near the top. The difference in gravity is great enough that the furfural gravitates to the bottom and the extract mixture is pumped to the heater at a temperature of about 450°F., or it may be as high as 550°F. From the heater it goes under pressure to the flash tower and the solvent is flashed-off. Then it passes to the atmospheric flash tower and the water and the furfural mixture goes to the stripper where steam and furfural is accumulated.

The refined oil mixture goes to the heater and back to the refined oil atmospheric flash tower from which the furfural is flashed-off. Furfural is col-

REQUIREMENTS OF AN IDEAL SOLVENT

An ideal solvent for extracting oils should possess the following properties:

"1. The solvent should be capable of extracting from petroleum oils the undesirable constituents so as to yield marketable products equal or superior to those obtained by other refining methods.

"2. The solubility of the solvent in the oil layer should be low, while that of the impurities in the solvent must be high.

"3. The solvent should be able to display its best solvent power at temperatures which do not require application of excessive quantities of heat or refrigeration, and at which the oil is sufficiently fluid to insure a good contact.

"4. The specific gravity of the solvent should be relatively high and interfacial tension low in order to obtain quick and complete separation into two liquid phases.

"5. The freezing point of the solvent should be low in order to avoid complications in handling in cold weather.

"6. The solvent must be stable and have no appreciable chemical action on the oil at temperatures encountered in refining or in separating the solvent from the oil.

"7. The boiling point of the solvent must be sufficiently low to insure its easy separation from the oil by distillation. It is also desirable that its vapor pressure at the extraction temperatures should not be exceptionally high in order to avoid the use of pressure equipment.

"8. The solvent must be available in large quantities and at low cost.

"9. The solvent should not exhibit exceptional corrosive properties that would require the use of expensive corrosion resistant materials.

"10. The solvent should not be of poisonous or of explosive nature in order to eliminate the danger of handling it at the plant.

"11. The quantity of solvent required for extracting the oil must not be excessive so as to insure a reasonable through-put in a plant of normal size."—From pages 111 and 112 of *Modern Methods of Refining Lubricating Oils*, by Vladimir A. Kalichevsky.

lected from the refined oil flash tower and stripper.

I checked the ideal qualities of a solvent, and furfural seems to check all right with all of them. It sells for less than 12 cents per lb., or about 91 cents per gal. It is very stable, and the loss is exceedingly low — between 0.03 and 0.06 percent.

Leader: Furfural was originally made for use in other industries, and it is being used for resin refining.

After the Quaker Oats Company got into the business they began to look around to see whether they could sell some of it to somebody else. Here is a brief resumé of the history and development of the process:

The Furfural Process

The Furfural Refining Process for treatment of hydrocarbon oil was patented August 18, 1925, by Eagon Eichwald and developed by The Texas Company and Royal Dutch Shell Company. It was not until 8 years later, however, that the first refinery installation was made using Furfural as a selective solvent. That was the Indian Refining Company plant at Lawrenceville, Illinois. The process is based on the fact that furfural is a good solvent for aromatic and highly unsaturated compounds, whereas it is a comparatively poor solvent for paraffinic and naphthenic constituents of hydrocarbon oil.

The successful application of furfural to a wide range of lubricating oils has been demonstrated in a large number of commercial operating installations. Waxey distillate oils ranging in viscosity of from 40 sec. to 170 sec. Saybolt at 210°F. have been successfully treated.

The Furfural Refining Process comprises the treatment of the oil with furfural, separation of a refined oil, and an extract, followed by recovery of the solvent for reuse in the refining process. The oil enters near the bottom of the counter-current extraction column and the furfural is supplied from a point near the top. The solvent, having a higher specific gravity than that of the oil, works downward. As it does so, it contacts the rising stream of oil and extracts therefrom the aromatic and unsaturated constituents that are removed from the bottom of the column along with the bulk of the furfural. A small amount of the furfural also remains dissolved in the refined oil or raffinate at the top of the column. This raffinate oil is subjected to a flash distillation, which is followed by steam, these two treatments combining to remove virtually every trace of furfural from the oil. The extract is treated similarly. The resulting solution of furfural and water is heated and the distillate comprising 35 percent furfural and 65 percent water stripped from the mixture. The distillate vapors are condensed and passed to a decanter, furfural saturated with about 5 percent water being withdrawn from the bottom. Heating of the wet furfural serves to dry it, the small amount of distillate thus obtained being returned to the furfural stripping column, along with the upper (or water layer) from the decanter, containing about 8.3 percent furfural.

The recovery process is very efficient. The losses amount to about 0.03 percent to 0.06 percent of the furfural used per cycle.

The Furfural Refining Process produces excellent yields of oils having high viscosity indices, as well as exceptional resistance to sludging and other deterioration effected at high temperature motor operation. The process is simple, economical, and easily controlled.

Reference

"Furfural as a Selective Solvent," by The Quaker Oats Company. *Refiner and Natural Gasoline Manufacturer*, September, 1940, page 90.

EDITOR'S NOTE: This series will be continued in an early issue.

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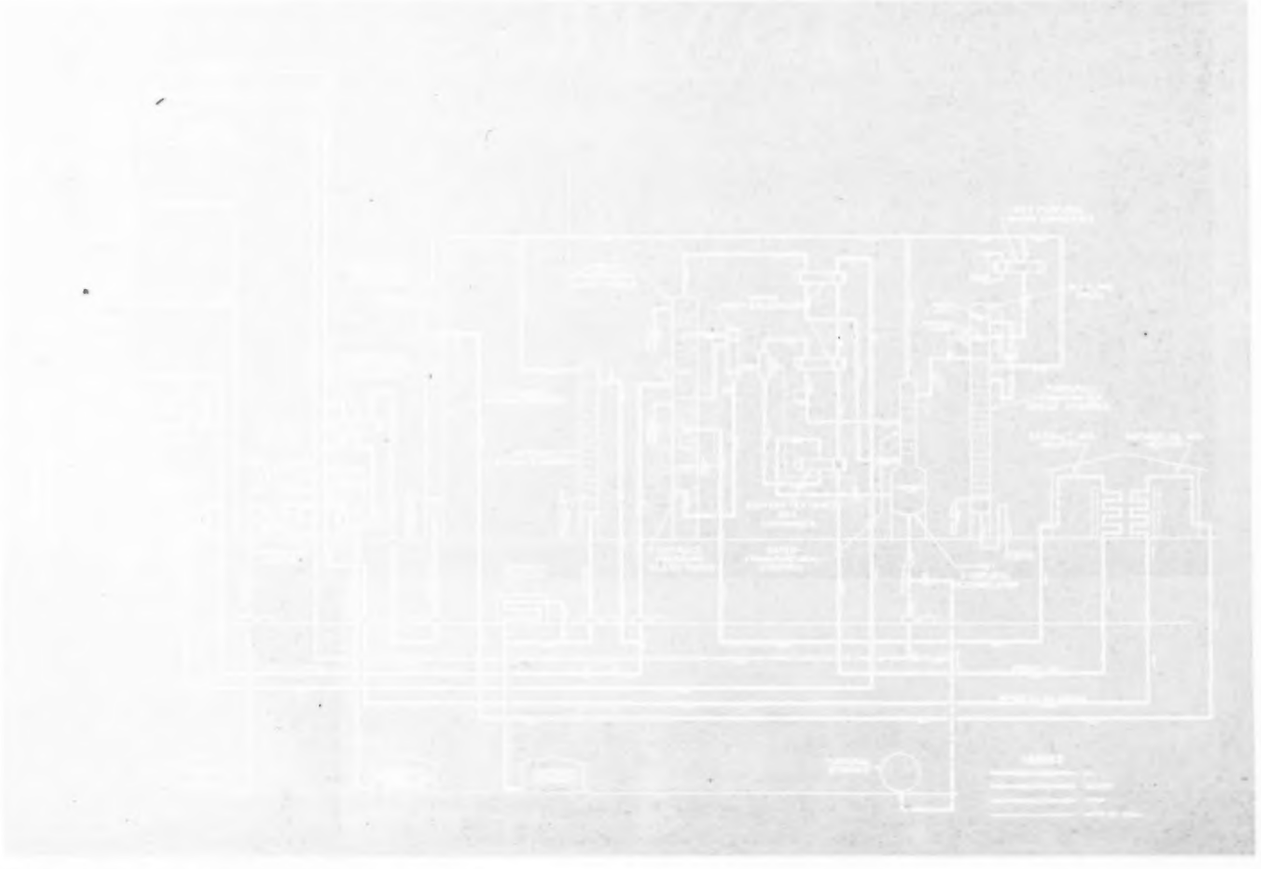
Fig. 14. Furfural refining unit *(Courtesy The Texaco Development Company)*



AN IMPORTANT NOTICE TO ALL USERS OF COOLING TOWERS

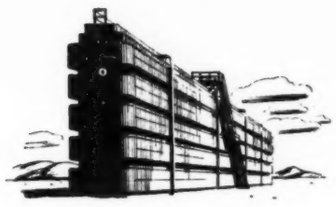
from the

COOLING TOWER DIVISION OF THE FLUOR CORPORATION LTD.

2500 South Atlantic Boulevard, Los Angeles, California

1919 R.C.A. Building, New York City, N.Y. · 545 William Penn Way, Pittsburgh, Penna. · 703 Fairfax Building, Kansas City, Mo. 1501 Mellie Esperson Building, Houston, Texas.

SINCE 1890



THE EFFECT OF CRITICAL COMPONENTS LIMITATIONS ON DELIVERY OF COOLING TOWERS

CRITICAL components limitations are exerting a sharp, industry-wide effect on delivery of cooling towers and they will continue to do so with increasing severity for the duration. In the interest of enabling users of cooling towers to secure the most prompt delivery, we feel an obligation to point out that critical components limitations are exerting a more pronounced effect on delivery of Mechanical Draft types while, for reasons stated herein, Fluor Atmospheric Aerator Cooling Towers can be delivered on schedule. Here, in Questions and Answers form, are the reasons why your interests will best be served if you specify Fluor Atmospheric Aerator Cooling Towers in every possible instance for the duration:

Q.: *"Why are Atmospheric Aerator Cooling Towers less affected by critical components limitations than Mechanical Draft types?"*

A.: Atmospheric Cooling Towers use the absolute minimum of critical materials. They do not require electric motors, reduction gears, propeller fans, fan rings, fan guards, motor supports, electric wiring or conduit which are the absolute essentials of the Mechanical Draft types. Many thousands of man-hours and machine-hours are required for the manufacture of this auxiliary equipment and critical transportation space is required for shipment from sub-manufacturers and reshipment to the job.

Q.: *"What positive delivery guarantee can be given when Mechanical Draft types are specified?"*

A.: As against an Atmospheric tower of comparable capacity, the absolute minimum required is twice as long and even this cannot be positive since the production of motors, fans, gears, etc., is always in greater part or absolute whole in the hands of sub-manufacturers and final delivery of the tower is dependent upon the ability of such sub-manufacturers to make their deliveries.

Q.: *"What positive delivery guarantee can be given when Fluor Atmospheric Aerator Cooling Towers are specified?"*

A.: As against Mechanical Draft types of comparable capacity, Fluor Atmospheric Aerator Cooling Towers can be delivered in one-half to one-third the time.

Q.: *"Will a Fluor Atmospheric Aerator Cooling Tower give performance efficiencies identical with those of the Mechanical Draft types?"*

A.: Yes, in the vast majority of cases. Of the minority cases, there are many instances where the difference in efficiency will be so slight as to make the Atmospheric type entirely suitable for wartime use. In the extremely few remaining cases, a Mechanical Draft type is the only answer.

Q.: *"What are the limiting factors which make specification of a Mechanical Draft type absolutely mandatory as in the aforementioned few remaining cases?"*

A.: The only limiting factors making specification of Mechanical Draft types absolutely mandatory are (1) lack of space for the erection of the Atmospheric type and (2) extremely subnormal wind conditions.

Q.: *"How can we be certain that a Fluor Atmospheric Aerator Cooling Tower is the absolute, correct specification under any conditions; or, if it is a substitute specification made necessary by wartime conditions, how can we know in advance just what the efficiency difference will be?"*

A.: Fluor engineers will gladly give specific, unbiased answers to either question after analysis of your problem. Fluor manufactures ALL types of cooling towers and holds no brief for either type; thus, our thinking is completely independent.

Q.: *"If analysis shows that a Mechanical Draft type is the only answer to our problem, what can be done?"*

A.: Fluor will gladly cooperate by furnishing expert documentary evidence of essential need as a means of assisting you in obtaining the necessary directive.

Q.: *"Has the development of the Fluor Atmospheric Aerator Cooling Tower kept pace with the development of Fluor Mechanical Draft Cooling Towers?"*

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P 420.11
P 367.

Recent Developments in Formation Logging

PETROLEUM ENGINEER

PART 2 (Concluded)

Feature

by Lester C. Uren
Professor of Petroleum Engineering, University of California

Temperature Logs

The geothermal gradient in any given locality is fairly constant and is only locally altered by conditions that are frequently of interest to those concerned with the problems of oil-field development. The normal gradient is about one degree Fahrenheit for each 60 ft. of depth, in some localities much greater, but this is appreciably altered in the vicinity of formational intervals in wells where gas is expanding or liquids are flowing from the well into the formation or vice versa; or where chemical change is occurring — as for example, in the setting and hardening of cement behind casings.[13]* Knowledge of these local variations in the normal temperature gradient is of assistance in locating the positions of water, oil and gas sands or gas-oil contacts in producing reservoirs; in determining variations in permeability of component members of an oil- and gas-producing zone; locating casing leaks or the source of water entering a well; or locating the top of a column of cement in the annular space behind a string of casing. Temperature surveys have the advantage over some other methods of gathering subsurface information, in that they can be applied inside of casing.

Types of instruments used in temperature surveys. Thermometers used in making temperature surveys in wells are of three types.[17] 1. The maximum mercury thermometer which, on being lowered into a well and withdrawn, indicates the maximum temperature reached. 2. The self-contained, continuously-recording type that is designed to be lowered through the well on a wire line and indicates the temperature at all depths on a record contained within the instrument, available only after the instrument has been withdrawn to the surface; and 3. The continuously-recording type, in which only an instrument responsive to thermal change is lowered into the well, while the temperature is simultaneously indicated or recorded on an instrument at the surface.

Maximum mercury thermometers have been widely used in studies of geothermal gradients in oil fields, but are capable of procuring temperature measurements only at intervals through the well. Inasmuch as the instrument has to be lowered into and withdrawn from the well for each observation or set of observations, the method is tedious and the record fragmentary. For these reasons, it is considered less suitable than the continuously recording types of thermometers.

A self-contained recording thermometer for use in wells is designed to register on a chart contained within the instrument a continuous record of the temperature to which it is subjected. A stylus that charts the record is responsive to a metallic coil or the pressure of an imprisoned gas or vapor that expands or contracts with a change in temperature. The chart is rotated under the stylus by a mechanism that can be correlated with the depth of the instrument in the well. Contained in a cylindrical casing, the device is lowered into the well on a piano wire or light wire cable. Such instruments have the advantage that they and their winding mechanism are light and require little power to operate, and can be run against high well pressures.

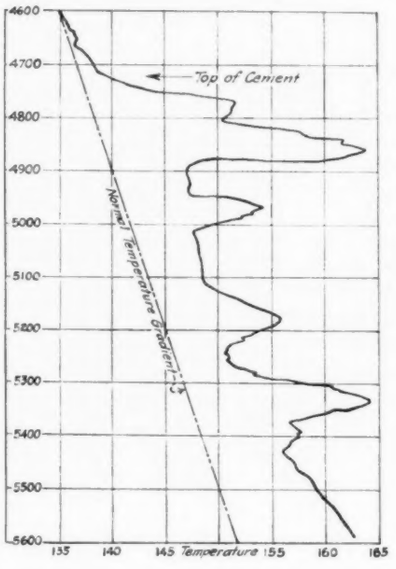

Fig. 4. Temperature log, showing method of locating top of cement

A surface-recording thermometer is of the electrical resistance type and must be lowered on a insulated conductor cable. The latter is expensive and being heavy, requires a power-driven winch to reel it. Indications of temperature at the level of the instrument in the well can be continuously observed on an electrical instrument at the surface, or a continuous record can be obtained that can be correlated on a chart against depth measurements on the cable.

A thermometer suitable for practical use in petroleum engineering operations should be capable of obtaining a continuous record, preferably one that can be observed as it is being recorded. It should be sufficiently sensitive to permit of recording to within 1°F. or less and it must have a low thermal lag so that it will quickly respond to changes in temperature. Furthermore, it must be ruggedly constructed to successfully withstand the conditions to which it is subjected in oil-well service. The electrical-resistance type of thermometer with continuous surface recording of temperature, appears to best meet these requirements.

The Schlumberger Well Surveying Corporation has developed a resistance type of thermometer designed to be run on the same insulated conductor cable used in connection with resistivity surveys.[15] Indeed, the two are often combined. Two of the insulated conductors are connected to a spool of resistance wire having a high temperature coefficient, that is lowered into the well. The wire of which the resistance spool is constructed, is insulated and the resistance that it offers to flow for current varies with the temperature. At the surface, the two conductors are connected to a source of direct current through a Wheatstone bridge or potentiometer, which measures the resistance of the circuit. By using three conductors connected through a bridge at the surface, the effect of the well temperature on the resistance of the cable can be compensated. The instrument can be run in holes as small as 2½ in. in diameter. The temperature experienced by the instrument lowered into the well is recorded on a surface instrument in the form of a continuous graph as abscissae against depth ordinates. Wells are surveyed with this apparatus at a rate of about 1000 ft. per hour.

The Lane-Wells Co. has also developed a temperature logging apparatus

*Complete bibliography published with Part 1 in February issue.

"... AT THE RISK OF HIS LIFE, ABOVE AND BEYOND THE CALL OF DUTY"

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—HUGHES TOOL COMPANY, Houston, Texas

that is available to the industry on a service basis.[16] The instrument lowered into the well contains a resistance coil wound in a groove on the exterior surface of a thin metallic tube that is surrounded by an outer concentric tube, the two tubes being welded together at the ends. The well fluid may thus pass through and around the resistance coil and the thin tubular protecting walls permit rapid diffusion of heat and prompt response of the instrument to temperature change. The thermometer is small, being only 1¾ in. in outside diameter, 17¾-in. long and weighing only 5 lb. The instrument is designed for accurate measurement of temperatures as high as 350°F. An insulated conductor cable of the type used in electrical logging or gun-perforating operations is employed to support the thermometer in the well, with facilities for indicating and recording the depth of the instrument at all times. At the surface, a Wheatstone bridge with self-contained power supply is employed to measure the electrical current flowing through the instrument circuit. A continuous record is automatically made on a 6-in. wide strip of photographic film, in the form of a log profile of temperature versus depth. Adjustable controls permit use of either of three depth scales and either of seven temperature scales. Temperature measurements are made as the instrument is lowered through the well. The operating speed may be varied depending upon the degree of accuracy required, greater accuracy being obtained with slow traversing speeds. A traversing rate of 150 ft. per minute is normally employed, but may be reduced to 20-ft. per minute or less for some purposes.[20]

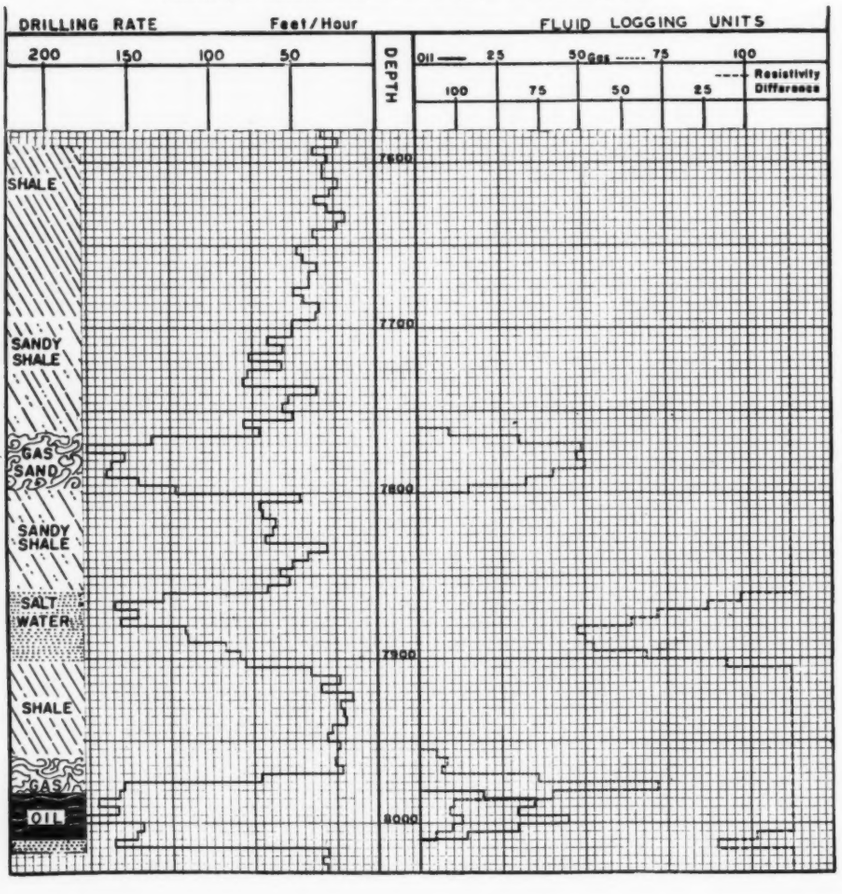
Applications of temperature surveys. One of the most useful purposes served by temperature logs is the location of oil and gas "pays" in limestone formations.[19] Because of the cooling effect of expanding gas, it is feasible to distinguish between gas-yielding and oil-yielding strata. Oil-yielding reservoir rocks also show a cool anomaly on the temperature log because of expansion of gas released from solution in the oil, but the cooling effect is generally less marked than in cases where the gas is free in the formation. Where both are present, it is usually possible to distinguish between them. Reflecting the normal temperature gradient, the graph customarily shows approximately constant increase in temperature with depth, but locally when influenced by the cooling effect of expanding gas, the temperature graph displays an abrupt departure from the normal trend. In some limestone fields, where a gas reservoir closely overlies the oil-bearing interval, it is important to set a column of casing to seal off the gas, just below the gas zone, without excluding any of the oil-producing zone. A temperature survey clearly shows the base of the gas zone so that casing may be set properly.[18]

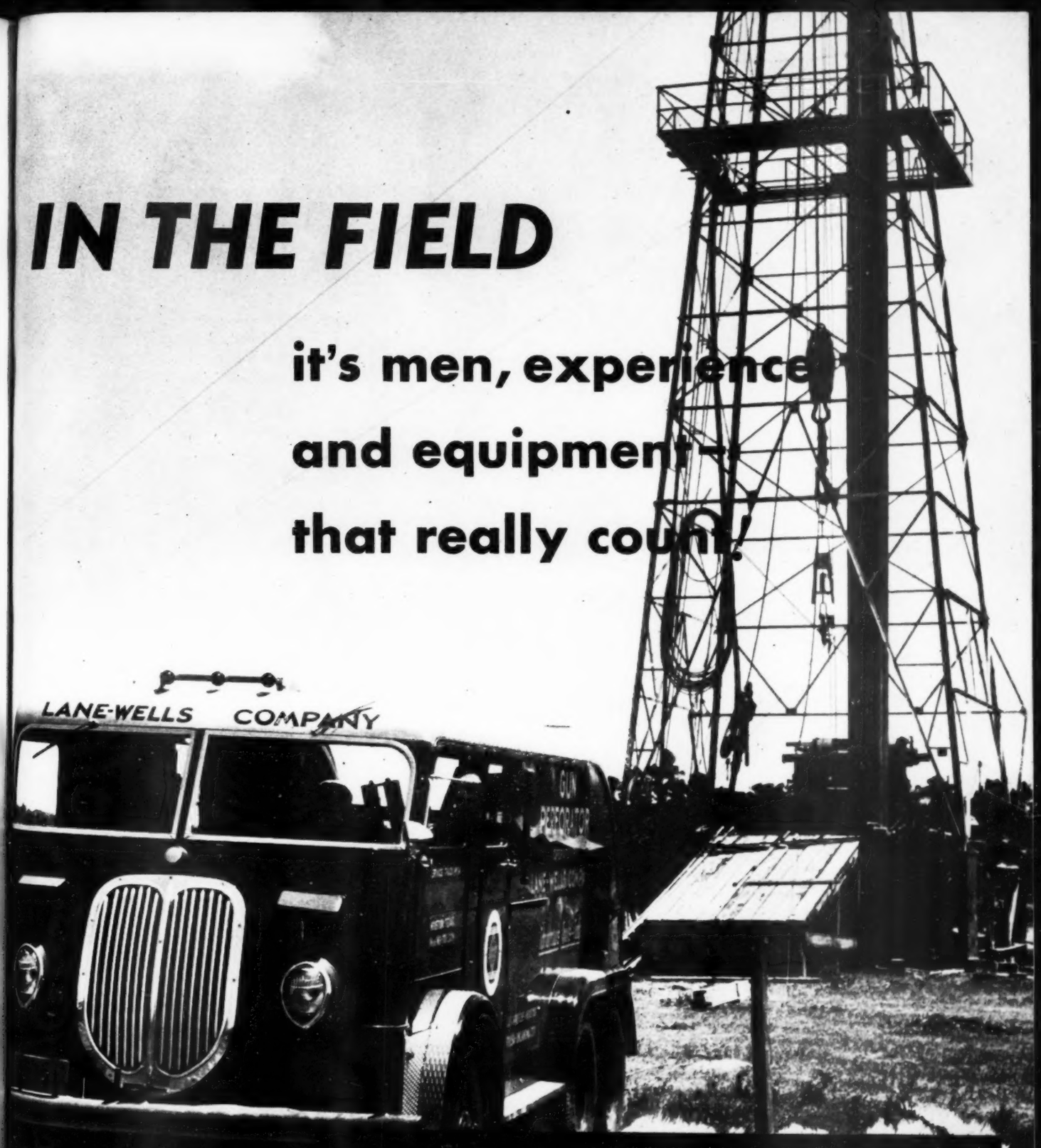
In cementing casing in wells, it is helpful to know, after the job is completed, the height to which the cement has risen in the annular space outside the pipe. This is often uncertain when determined by volume computations because of variation in the diameter of the well, channelling of the cement and tendency of permeable formations to absorb some of the cement.[15] The chemical changes involved in the setting and hardening of cement are exothermic and the heat developed is apparent on the temperature survey for many days after the cement is in place and has taken its initial set, even though the heat must penetrate the intervening casing. Fig. 4 presents results of a typical temperature survey illustrating the effects of cement in process of hardening.

Temperature logs are at times helpful in correlating formations from well to well, it being frequently possible to observe some common temperature anomaly that is peculiar to a certain stratum or group of strata in the temperature logs of near-by wells. In a well drilled by the rotary method, the temperature of the circulating fluid differs materially from that of the formation with which it is in contact, being lower at the bottom and higher at the top of the column of fluid in the well. When circulation is stopped, heat from the formations exposed in the walls of the well will tend to bring temperature equilibrium with the formational temperature. Fluid in the upper part of the hole will become cooler and that toward the bottom warmer. However, the rapidity of heat exchange will depend upon the nature of the rock strata traversed by the well. For example, sands containing water have a high thermal conductivity and capacity and will release their heat to the well fluid more rapidly than shales.[14] Oil sands, being poor conductors of heat, will release their heat less rapidly than water sands. A depth-temperature log recorded shortly after circulation has stopped, may thus distinguish to some extent between different strata according to their thermal conductivities, and similar records obtained in near-by wells will at times suggest correlations.

Fig. 5. Illustrating type of record procured in system of logging wells by inspection of drilling fluid

(Courtesy of Baroid Sales Division, National Lead Company)





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Logging by Inspection of Drilling Fluid

A system of logging depth, thickness, character, and fluid content of formations penetrated in rotary drilling, in which most of the necessary data are automatically recorded as the well is drilled, has been developed and is offered to the industry on a service basis by the Baroid Sales Division of the National Lead Company.[21] The methods employed depend upon tests that are continuously made to detect changes in the liquid phase of the drilling fluid and the rate of penetration of the drill. The equipment employed is elaborate and intricate and is permanently mounted in a house-type trailer that is left at the well in the care of a skilled operator while drilling is in progress. The trailer is also equipped with instruments employed in testing the physical properties of drilling fluids and in core inspection and analysis. Except for electrical logging, the equipment provided is thus capable of giving the operator a complete logging and field-laboratory service.[23]

In the process of drilling, the bit disintegrates the formation in its path and fluids present in the pore spaces of the rock become a part of the liquid phase of the drilling fluid. Though the amounts of oil, gas or salt water thus added to the drilling fluid are small, they are sufficient to be clearly apparent in the delicate tests that are applied to the fluid after it reaches the surface. In order to correlate the fluid detected by such tests with the stratum from which it came, it is necessary to take into account the time intervening between the drilling of the material and the delivery of it at the surface in the drilling fluid. A log of rate of penetration versus depth is also obtained and differences in the recorded rate of penetration may be used as an index of the lithologic properties of the strata penetrated. The depth to the top and bottom of each sand stratum is thus disclosed and sands are clearly differentiated from shales.

The test equipment employed in this system of logging may be divided into two groups: that used for detection of oil, gas, and salt water in the drilling fluid returns, and that necessary in registering the depth of the well, the rate of penetration and rate of drilling fluid circulation. The latter must be known to correlate surface observations with the depths to which they relate. The instruments used are electrically operated and power for operating them is obtained either from the source that drives the drilling rig, or from a 1½-kw. gasoline - engine - driven generator carried as a part of the equipment of the trailer laboratory.[25]

Depth determinations are made by two independent means: first, the drilling-rate record, which continuously and automatically is recorded against depth. By this means the tops and bottoms of sands and more permeable beds encountered in drilling are indicated. This record is supplemented by a second determination that depends upon a volumetric metering of the circulating fluid and the time necessary for formation samples to travel from the bottom of the well to the surface. A depth recorder in the trailer-laboratory continuously indicates the depth of the well and the distance of the bit off bottom and drives a chart in synchronism with the rate of increase in depth. The sclerograph, or drilling-rate meter, operates in conjunction with the depth recorder, the rate of penetration being determined by measuring the volume of fluid displaced by the slush pump, as indicated by a pump-cycle counter. The number of pump cycles necessary to bring a sample from the bottom of the well to the surface is a factor that must be known in this system of logging, and is determined from time to time by actual test. The necessary time, of course, increases with the depth of the well, averaging about six minutes per thousand feet of depth. With the types of slush pumps used in rotary drilling, the volume of drilling fluid displaced per cycle is practically constant, and the number of pump cycles necessary to bring fluid from the bottom of the well to the surface becomes a measure of its depth. A larger meter shows at all times, the rate at which the pump is operating and this is also indicated on the record chart in "fluid units".

Minute quantities of gas entrained in the drilling fluid delivered at the surface are identified by a "gas detector". A motor-driven vacuum pump constantly draws air through a trap mounted on the drilling fluid flow-line, and thence through a flexible hose to the trailer laboratory where it passes through a filter, a humidifier, a flow meter, and thence to a "hot-wire" bridge-type gas detector. In the latter, two filaments maintained at different temperatures, make it possible to distinguish between "wet" and "dry" gas. This instrument can detect as little as 0.01 cu. ft. of gas per hour mixed with air drawn from the trap. The gas detector is connected with the recording apparatus so that its signal appears on the recorder chart. Facilities are also provided to test core samples for gas with this apparatus.

Ultra-violet light is used as a means of identifying oil particles in the drilling fluid. A sample of the mud stream is placed in a dish, diluted with water, a viscosity and emulsion "breaker" is added and the dish and sample placed in a specially designed "viewing box". The latter is equipped with a source of ultra-violet light and an alternate source of visible light with a magnifying eyepiece for inspection of the sample. Under ultra-violet light, crude oil fluoresces, and if present in the mud sample, appears in the form of bright specks on a dark background. By observing a fluorescent spot and then switching on the visible light, it is possible to distinguish between crude petroleum and other oils or greases that may accidentally get into the mud—from the swivel for example. Fluorescence due to presence of petroleum in the drilling fluid is marked only when the oil is first produced and gradually disappears if the mud containing the oil is circulated repeatedly through the well. To supply dependable drilling-fluid samples for testing, a continuous sampler is placed in the mud ditch. This is in the form of a revolving wheel that takes a small sample with each revolution and deposits it in a sample container. By this means, an average mud sample for any depth interval is obtained. With the equipment described, it is possible to detect oil in drilling fluid when the concentration is only ten parts per million.

Salt water added to the drilling fluid as a result of disintegration of rock strata by the drill, is detected by an electrical device. Electrodes placed in the flow line and in the pump suction, record the electrical resistance of the ingoing and outgoing drilling fluid. Superimposing the input resistance record for a portion of the ingoing mud stream, over the recorded resistance of the same portion of fluid as it issues from the well, discloses any change that may occur as a result of passage through the drilling zone. If the fluid is more conductive after passage through the well, salt water has been added. Making due allowance for time lag, the recording apparatus automatically indicates the difference in resistivity between the ingoing and outgoing fluid. For successful logging of salt water "shows", the liquid phase of the drilling fluid must be completely fresh.

Fig. 5 presents a typical log developed from records taken with the apparatus described in the foregoing paragraphs. An interpretive graphic log drawn to the same vertical scale has been superimposed on the left edge of the record. The value of a system of logging in which all of these useful indicators will be made known promptly, as drilling proceeds, will be apparent. Such a record, supplemented by an electrical log and occasional cores, gives a fairly complete subsurface picture and accurate and timely information of the location of all oil and gas sands found in the course of drilling.

—— ☆ ☆ ☆ ——

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P 624.5
P 773.53

Certain Aspects of Cooling Tower Design and Operation*

PART 2 (Concluded)

by R. C. Kelly
Engineer, The Fluor Corporation, Ltd.

Tower Capacity Examples

To enable operating engineers and plant operators to check the performance of existing atmospheric towers and to assist design engineers in quickly estimating tower sizes, a set of curves are shown, with a simple method of approximating average requirements.

Assume the following condition: 1500 g.p.m. to be cooled from 90°F. to 75°F., with a 3-mile wind and a 70° wet bulb.

Problem 1:

The problem is to obtain the number

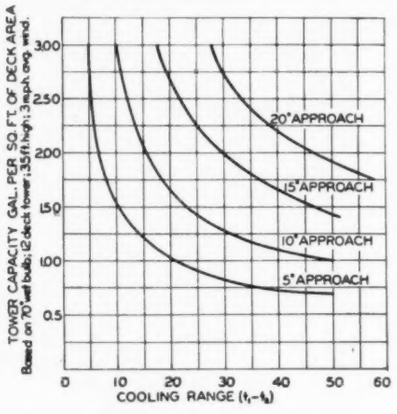


Fig. 5. Atmospheric tower capacity curves

of 6 ft. sections of a 35 ft. high, 12 ft. wide, 12-deck tower.

From these conditions:

t_1 (inlet temperature) $= 90°F.$
t_2 (final temperature) $= 75°F.$
t_{wb} (wet bulb temperature) $= 70°F.$

The cooling range $(t_1 - t_2)$ is therefore 15° and the approach $(t_2 - t_{wb})$ is 5°. C = concentration per sq. ft. of horizontal deck area obtained from Fig. 5. A (area of one standard tower section, 12 ft. wide, 6 ft. long) = 72 sq. ft.

N = Number of 12 ft. wide, 6 ft. long, tower sections.

To determine the number of sections under the above conditions, the following equation is used:

$$\frac{\text{g.p.m.}}{C \times A} = N$$

From Fig. 5. C for 35 ft. high tower, for an approach of 5° and a $t_1 - t_2$ of 15° = 1.17. Then substituting in the above equation:

$$\frac{1500}{1.17 \times 72} = 17.8$$

Therefore, under these conditions an 18-section tower 35 ft. high is required.

Problem 2:

If the wet bulb is other than 70° upon which Problem 1 is based, a wet bulb correction factor must be used. This factor is C_{wb}, obtained from the wet bulb curve Fig. 6. The problem then becomes one of figuring the number of sections required with the same tower height.

Conditions to be met:

Assuming 65° wet bulb, 5° approach, 15° range. To determine the number of sections under these conditions, the following equation is used:

$$\frac{\text{g.p.m.}}{C \times C_{wb} \times A} = N$$

C for 35 ft. high tower for an approach of 5° and a $t_1 - t_2$ of 15° : 1.17. Fig. 5. Correction factor for wet bulb (C_{wb}) is obtained from Fig. 6 and in this problem = 0.85.

Then substituting in the above equation:

$$\frac{1500}{1.17 \times 0.85 \times 0.72} = 20.8$$

Therefore, under these conditions a 21-section tower 35 ft. high is required.

Problem 3:

Assuming that 35-ft. high tower does not meet your requirements due to ratio of range to approach, then a tower of greater or lesser height must be figured. Therefore, a height correction factor must be used. This factor, C_h, is obtained from the height curve Fig. 7. Required a tower 51 ft. high, instead of 35 ft. high, for conditions stated in Problem 1.

To determine the number of sections under the above conditions, the following equation is used.

$$\frac{\text{g.p.m.}}{C \times C_h \times A} = N$$

C_h, correction factor for height is obtained from Fig. 7 and in this problem = 1.63.

Then substituting in the above equation:

$$\frac{1500}{1.17 \times 1.63 \times 72} = 10.9$$

Therefore, under these conditions an 11-section tower 51 ft. high would be required. In this last problem if the wet bulb is other than 70°, the wet bulb correction factor (C_{wb}) becomes a part of the equation:

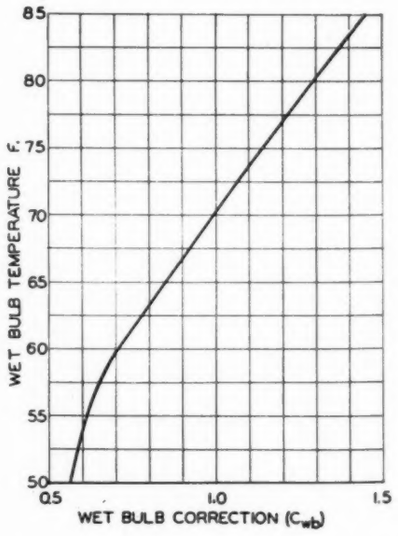
$$\frac{\text{g.p.m.}}{C \times C_{wb} \times C_h \times A} = N$$

The data used for the preparation of the curves are generally conservative and do not necessarily represent the most economical selection for every cooling job in every locality.

Further correction for variation of tower size with approach of the water temperature to the wet bulb temperature and wind velocity may be estimated as follows:

In this brief resume of tower design factors, we have purposely omitted corrections for elevation above sea-level

Fig. 6. Wet bulb performance factor



*Presented at California Natural Gasoline Association Monthly Meeting, Downey, California, December 3, 1942.

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R = Center line radius of fitting, inches.
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TABLE 1

Approach to wet bulb temp. desired, °F.	Relative tower length
5	4.5
10	2.5
15	1.5
20	1.0
25	0.8
30	0.5

(barometric reading), limiting concentrations of water on decks of tower, limiting ratios of cooling range to wet bulb approach, and low wet bulb considerations. Adequate discussion of these elements of design will be undertaken at a later date, but from the data above it can be seen that for any given heat load in a system the tower size will increase if low wind velocities govern the design or if high wet bulb conditions govern, and, if a higher tower is selected

TABLE 2

Design wind velocity	Relative tower length
1	1.55
2	1.40
3	1.25
4	1.10
5	1.00
6	0.95

to minimize ground space requirements and basin costs, the pumping horsepower increases proportionately.

Generally speaking, the greater the cooling range required, or the closer the approach to the wet bulb temperature desired, the higher the tower should be —up to economical structural limits, or to a height such that, without proper control, the water would be blown over to one side of the tower. Tower height up to 60 ft. is standard design, although 35 ft. height is average. Likewise, concentrations as low as ¾ g.p.m. per sq. ft. of cross-sectional deck area are possible, although 1.5 to 2.5 g.p.m. per sq. ft. is considered a general average for the majority of atmospheric towers in use. In applications of low concentration in which the tower loading is less than 1 g.p.m. per sq. ft., special precaution must be taken to prevent the accumulation of water on the lee side of the structure and to prevent excessive drift loss from the tower. Drift loss, the term applied to the actual suspended water carry-over from the tower, can be controlled for any normal wind conditions by providing drift eliminators or baffles at the point of discharge of the vapor from the tower. Such drift eliminators or baffles must be designed into the structure as an integral element of the unit. Most drift eliminators are arranged so that a definite change in direction of flow of the vapor will take place just as the leaving air passes the lee edge

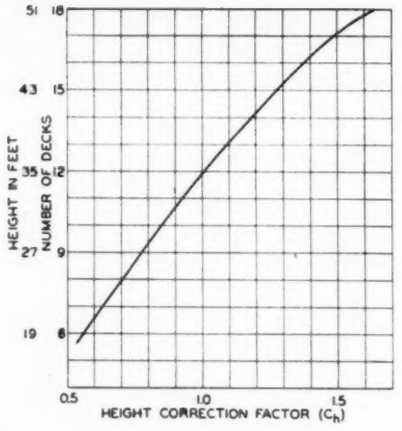


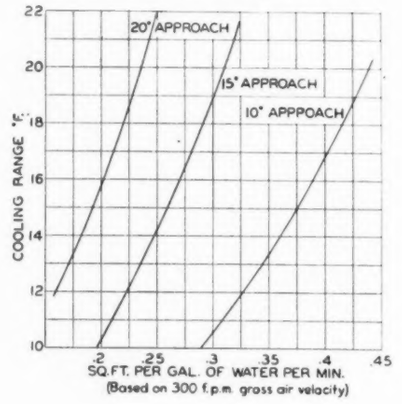
Fig. 7. Tower height performance factor

of the decks. This change in direction of flow causes the air to turn sharply and the inertia in the particles of water causes the entrained moisture to continue on its path to impingement on the baffles. The actual drift loss from a properly designed atmospheric tower under average wind conditions need not exceed 0.2 percent of the total water being circulated, approximately equal to the drift loss from an average mechanical draft tower.

Mechanical Draft Towers

The mechanical draft towers, both forced- and induced-draft types, bring into the cooling tower design study three important elements of control of the air entering the structure—volume, velocity, and distribution. By means of fans, blowing fresh air horizontally into the forced-draft tower or drawing saturated air vertically out of the induced-draft tower, a predetermined quantity of air at a controlled velocity and direction is caused to contact the falling water intimately and with considerable

Fig. 8. Nominal area required per gal. of circulating water for an average mechanical draft tower 20 to 26 ft. high



turbulence. The gross result is a tower requiring less ground space and less pumping horsepower—advantages that are somewhat offset by power consumed by fans and by the inherent mechanical problems of maintaining equipment in saturated vapor at elevated temperatures.

To summarize the design data for mechanical draft towers three sets of data are shown in graph form for easy reading. In Fig. 8 is shown the nominal area required per gallon of circulating water for an average tower 20 to 26 ft. high in which closely spaced decks fill approximately 12 to 15 ft. vertical dimension. Decks are designed to break the fall of water and hold a portion of the water in contact with the air for as long a period of time as economically desirable.

Carrying forward the earlier comparison of ground space required, we shall assume a heat load of 50,000,000 B.t.u. per hr., 10 times as great as could be handled by the 4000 sq. ft. spray pond, and shall dissipate the total quantity of heat by the circulation of 5000 g.p.m. taking a 20° cooling range and a 10° approach to a 70° wet bulb temperature. In this situation $t_1 = 100°F.$, $t_2 = 80°F.$, and $t_{wb} = 70°F.$

From Fig. 8, which shows approximate values for one particular type tower filling, we see that 0.44 sq. ft. of tower area is required per gal. per min. of water circulated, so the total theoretical area at 70° wet bulb (unity) is $5000 \times 0.44 = 2200$ sq. ft. This represents a capacity of 22,727 B.t.u. per hr. per sq. ft. or 45.6 gal. degrees per sq. ft.

The effect of wet bulb temperature with respect to the area required is theoretically approximated in Table 3. A calculated area, based on the values in Fig. 8 for a 70° wet bulb condition must be corrected by the factor value shown.

TABLE 3

t_{wb}	Factor	t_{wb}	Factor
50	1.66	70	1.00
55	1.45	75	0.886
60	1.28	80	0.785
65	1.13	85	0.697

From this table it can be seen that the theoretical area required in our example need not be corrected for wet bulb temperature and therefore a tower of 2200 sq. ft. horizontal ground area will be selected. Because economical production of standard towers dictates a minimum number of sizes, the usual selection is made in increments of 4, 6, or 8 ft. in length and width. Our case therefore falls into a standard four-cell tower in which 18 ft. by 30 ft. cells of 540 sq. ft. each will total 2160 sq. ft. Within reasonable limits the shortage of actual

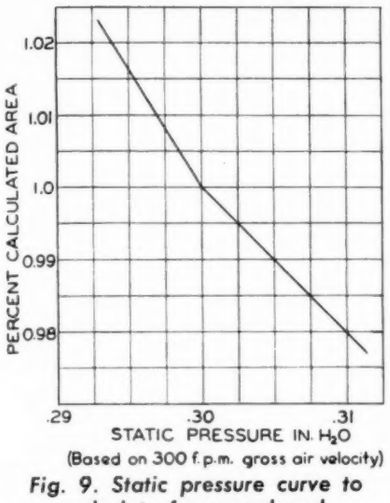


Fig. 9. Static pressure curve to calculate fan speed and horsepower

area can be compensated for by an increase in air velocity through the tower, which in turn necessitates an increase in horsepower input to the fan. An increase in velocity increases the resistance to flow of air through the tower and enters the computation as an increase in static pressure as shown in approximately 1.85 percent. From the curve (Fig. 9) a static pressure of 0.3100 is used to calculate the fan speed and horsepower. These calculations must be based on the particular fan being used and are a function of inherent resistance to air flow in any particular tower and the velocity required in that tower. Today air velocities in standard counter-current flow towers range from 250 ft. per min. up to 400 ft. per min., depending upon the amount of "filling" or deck surface in the unit, and upon the concentration of water in g.p.m. per sq. ft. of horizontal area of the structure. If a tower is built to accommodate a certain quantity of water on the basis of 300 ft. per min. air velocity through the filling, an increase in water concentration will offer greater resistance to the air flow, and therefore, in order to maintain the proper air-water volumetric-ratio, the fans must turn faster or the pitch of the blades be increased. If standard synchronous speed electric gearmotor drives are used the speed is fixed and pitch increase, with resultant increase in input horsepower, is the simplest means of maintaining the necessary flow of air through the tower.

If a tower is basically designed for maximum efficiency at a concentration of 2 g.p.m. per sq. ft. and counter-current air flow of 300 ft. per min., the correction for concentration from the 2 g.p.m.—300 ft. per min. base is shown in Fig. 10. The fan input horsepower calculated from the 2 g.p.m.—300 ft. per min. base must be corrected by the amount shown for C_{hp} on the curve. In the example, the concentration is equal to $\frac{5000}{2160} = 2.32$ g.p.m. per sq. ft., for which value the base horsepower must be multiplied by 1.012.

This concentration correction suggests a particular problem in mechanical draft cooling tower design. If the heat exchanger specification indicates that a 20° temperature rise is desired, the cooling tower is often designed for a 20° cooling range with a certain water rate. Fans, motors and gears, and the distributing system within the tower are selected for this particular condition and the equipment is installed. After some operating experience the plant engineer may find that a more economical overall plant operation could be achieved with greater water circulation and less cooling range for a lower temperature rise in the exchangers. This means greater load on the distributing system, an increase in fan horsepower and a change in the air-water ratio of the tower. To allow for such contingencies it is well for the purchaser of mechanical towers to specify the limits within which the equipment may be expected to dissipate a certain quantity of heat so the manufacturer of the tower can provide in the distributing system, in the range of pitch settings of the fan blades and in the horsepower of the motors for such variations. The use of multispeed motors, steam turbines, or gas engine drives, all with variable speeds available, is a partial answer to the problem. The atmospheric tower is, of course, less critical in this respect. Increases in water rate up to 100 percent have been tested and found to decrease the overall efficiency of the atmospheric tower as little as 7 percent.

Without regard for the immediate aspect of critical materials such as steel, iron, copper, etc., and available power and man hours of labor and machine time, a few comments pertinent to a comparison, are made with reference to an average cooling tower installation.

In the average industrial plant cooling circuit the basic requirement is heat dissipation, without critical regard for temperature. In some plants constant temperature water is essential. Temperature fluctuations will occur in both types of towers with fluctuations in wet bulb temperature. In mechanical draft towers the change in off-tower water temperatures can be held to a minimum by adjusting the pitch of the fan blades or reducing the speed of the fans or by bypassing some of the hot water directly into the basin by means of thermostatically controlled, mechanically actuated valves. In atmospheric towers, with the wind velocity also affecting the water temperature, bypass lines to secondary distributing systems or directly to the basin can be installed to effect the same degree of temperature control as attainable with the mechanical draft towers.

Although wind definitely affects mechanical tower performance, the effect is seldom more than a 10 percent decrease in capacity due solely to reduced air flow through the tower. Another element of design enters the picture, however, when the wind causes the hot, saturated vapors discharging from the tower to recirculate back into the air intake of the tower. This means the "entering air" is at a higher wet bulb temperature and higher degree of saturation. The water temperature rises in approximate proportion to the increase in wet bulb.

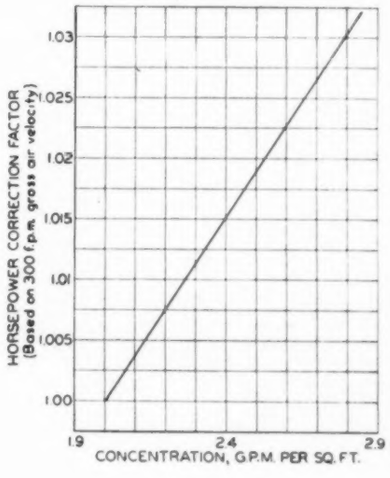
One large user of both induced- and forced-draft towers determined by actual field test that it was true operating economy to build the discharge stacks of their towers up to a point 50 ft. above the ground, or 25 ft. above the top of a 25 ft. high tower. By thus discharging the hot saturated vapors the moisture and the heat was so diffused into surrounding fresh air that the effect of recycling was negligible.

It is extremely difficult to anticipate the net result of recycling. Some engineers prefer to specify "spare cells" in addition to the actual required number. Others merely select a higher design wet bulb condition. Neither of these methods fully protects the purchaser. Full discussion of the value of each degree increment of cooling usually leads to a satisfactory compromise between adequate tower and cost of installation and operation.

Response to the common question, "Which type tower is best?", is a matter of opinion, in one view, and application

(Continued on Page 98)

Fig. 10. Curve for correction of concentration from the 2 g.p.m. —300 ft. per min. base



where Pipe Lines are..

WIGGINS *Pontoon Roof Tanks*

serve a fighting nation

LIKE giant arteries, the nation's pipe lines are carrying vital oil from regions of abundance to areas where military operations call for *more oil faster*. Wiggins Pontoon Roof Tanks have long served the oil industry, at refineries, bulk stations and recycling plants, as efficient vapor-saving units. It is natural, therefore, that, at the nation's pipe line stations, tanks equipped with Wiggins Pontoon Roofs should also be performing a valuable service.

The floating roof principle, as exemplified by the Wiggins Pontoon Roof, is the accepted method in the oil industry for *efficiently* and *economically* stopping evaporating losses from working tanks handling volatile liquids.

• We also build tanks to meet many problems existing in the handling and storing of essential products in the oil industry. Hortonspheres, Hortonspheroids and cylindrical vessels for pressure storage are a few of the products fabricated at our plants.

FABRICATORS OF SPECIAL STEEL PLATE WORK FOR MILITARY, NAVAL AND WAR PRODUCTION USES.

Wiggins Pontoon Roofs—whether installed on existing tanks or completely new tankage—float directly on liquid, blanketing the surface at all levels, thus preventing all filling losses and practically all breathing losses as well as reducing fire hazard by eliminating the vapor space in a tank.

Wiggins Pontoon Roofs consist primarily of a pontoon deck, a special type of seal which closes the space between the deck and the tank shell, roof supports, fittings and a guide to keep roof from rotating. Pontoon roofs may be installed on new or existing butt-welded, lap-welded or riveted tanks 15 ft. in diameter or larger.

CHICAGO BRIDGE

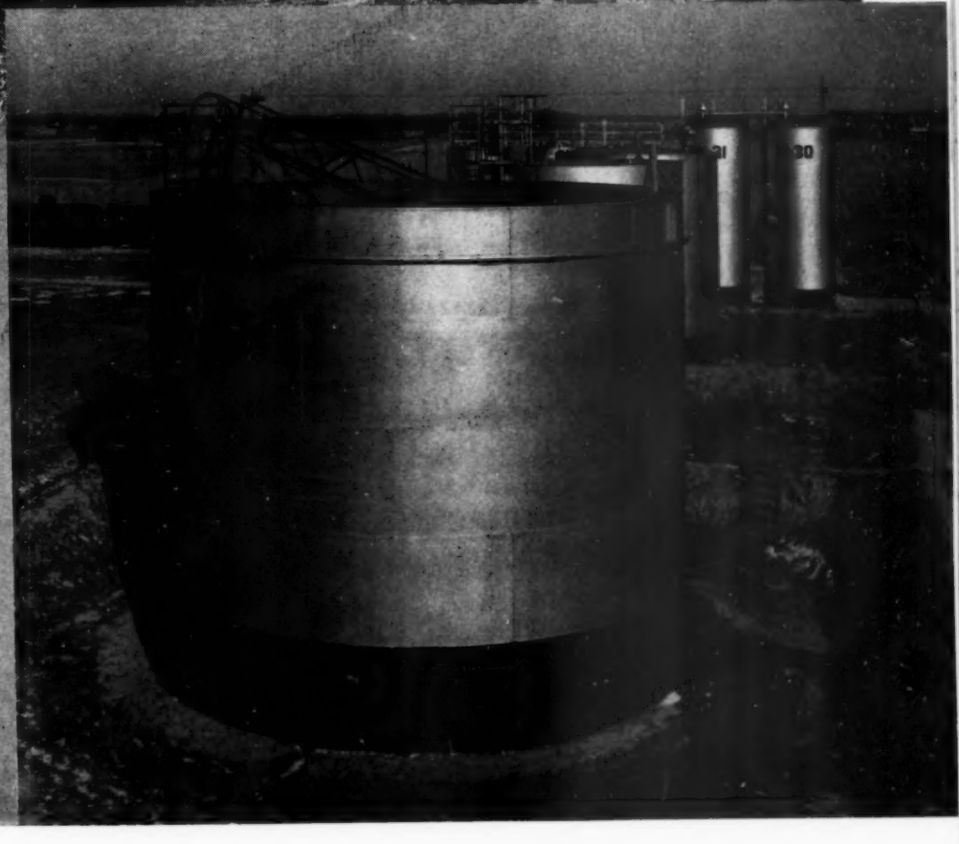
BIRMINGHAM - CHICAGO - CLEVELAND - HAVANA - HOUSTON

"Life Lines"

Above—The use of Wiggins Pontoon Roofs on working tanks is illustrated by this installation in Ohio on a 100-ft. diameter, 55,000-bbl. pipe line tank.

•

Right—The 5,000-bbl. tank in foreground and the 2,000-bbl. tank immediately behind it are equipped with Wiggins Pontoon Roofs. They are located at a pipe line station in Indiana.



& IRON COMPANY

NEW YORK - PHILADELPHIA - SAN FRANCISCO - TULSA - WASHNGTON

(Continued from Page 95)

in another. The true analysis rests on the facts of each individual situation. If open space near the plant site is available, for normal thermal ranges an atmospheric tower will do the same cooling job for less initial cost and less operating and maintenance cost than a mechanical draft tower. If power costs are exceptionally low, and a maintenance crew is available, the mechanical draft tower might be the economical selection. If unusually high (80° or more) wet bulb conditions prevail for relatively long periods of time with no appreciable wind, the mechanical tower has certain distinct advantages.

Considering only initial cost, if towers of like quality in workmanship and materials are compared for a plant that has available open space, the atmospheric tower usually will be lower in first cost for average wind velocities greater than 2.5 miles per hour. Below this average, for comparable cooling, the mechanical tower will represent a smaller investment.

In operating cost, if both fan horsepower and pump horsepower are evaluated, the atmospheric-type unit will show a saving in almost all cases. In locations in which the operating limits of the atmospheric unit are approached —in high wet bulb areas where high relative humidities prevail during periods of unusually low wind velocity— the mechanical draft towers show a distinct advantage to the operator.

As mechanical draft tower designs improve, as efficiencies are increased, and power costs are decreased, the economical applications of mechanical towers will increase in number. Improvement in fan design and materials of construction of the mechanical parts of the "power towers" will go far in widening the scope of their applications. The industry at large is spending increasing amounts of money on research toward a more efficient, simple mechanism so that it may offer to the industrial users a more efficient, more economical cooling unit.

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P 936.

Manufacturers Drive to Recover Used Pump Parts Containing Scarce Alloys

ALL manufacturers of subsurface oil-well pumps on the Pacific Coast are coöperating fully in the Government's campaign for collecting used seats, balls, and companion subsurface pump parts containing scarce alloys, such as stainless steel, tool steel, nonferrous metals, etc. The drive, initiated by H. M. Kent, chief of the Salvage Section, Office of Petroleum Administor for War, was officially begun on January 1, 1943.

The Western manufacturers have agreed to act as central collection agents and are doing everything possible to inform producers, distributors, and supply stores of the drive. In contacting those who have used parts or who will help in the collection, the manufacturers are stressing the urgent need for turning in seats and balls so that scarce alloys will be available for making essential replacement parts. It is being pointed out that the nearer the petroleum industry comes to recovering 100 percent of its needs as a result of the drive, the more inclined the War Production Board will be to grant 100 percent of the industry's requirements.

Producers are being asked to turn in all worn parts on hand immediately instead of holding them. To discourage retaining excessive quantities of old parts until a comparable number of new parts are ordered, a "credit" plan has been established similar to the now famous tooth paste tube plan. No monetary credit will be involved but "unit credit" will be given for salvaged parts contributed. Under this plan notations will be made of the balls, seats and other parts turned in by each producer. In effect, this system will allow a producer to obtain one new part when needed for every used part for which he has received credit by previous salvage.

Kent related the absolute necessity for such a drive to the various manufacturers on November 11, 1942, and asked for their suggestions. He pointed out that participation in a program of this type was the petroleum industry's patriotic duty. After considering their replies, the following points were proposed as a basis for organizing and conducting the campaign:

Functions of the manufacturer are as follows:

1. To act as a central collection point for all alloyed parts gathered in the drive.

2. To maintain a record of the volume of scrap alloy material recovered in the drive, as a means of augmenting the supply of metals utilized in the manufacture of new parts; and to keep the Office of Petroleum Administrator advised periodically of these quantities.

3. To segregate the parts by alloy content, advising the Office of Petroleum Administrator periodically of the quantities on hand so that appropriate steps can be taken by the War Production Board to facilitate the movement of the materials to the proper remelting points.

4. To absorb any costs involved in the collection, segregation, and disposition of materials not otherwise recovered in the transaction.

Functions of the jobber or distributor are:

1. To set up a method of extending "unit credit" to the supply stores for the number of balls, seats, etc., turned in, to apply against future purchases of new balls and seats.

2. To prepare a letter to outlets advising them of the drive, outlining the procedure for conducting the drive, and soliciting their wholehearted cooperation in this program.

3. To arrange for the shipment of scrap parts from the primary collection points (the supply stores) to the central collection points (the manufacturers).

4. To absorb any costs incurred in the collection drive.

Functions of the supply store are:

1. To act is a primary collection point for worn pump parts containing scarce alloys.

2. To set up a method of extending "unit credit" to customers for the number of worn balls, seats, etc., turned in.

3. To work with jobber or manufacturer in arranging for frequent consignment of worn parts on hand.

4. To encourage by word of mouth and otherwise, the full active coöperation of all producers in this collection drive.

—— ☆ ☆ ☆ ——

The "Big Inch"—New Monument to Pipe-Line Engineers

RALPH K. DAVIES

by Ralph K. Davies
Deputy Petroleum Administrator for War

SKILL, sweat, and the stimulus of war necessity are spurring American engineers to progressively greater heights of creative accomplishment. Among these, unspectacular but scarcely rivaled for the importance of its service to our country, the "Big Inch" War Emergency Pipeline stands with the finest of these accomplishments.

Many of the great, new monuments to the engineering genius of America must remain without the recognition that is their due until their grim application in the cauldron of global war is done, and their value, tested on the proving grounds of unconditional victory over our enemies, can be turned to the constructive pursuits of peaceful progress. Other working tributes to the engineer will be obscured by the simple fact that they serve obscurely.

It is fortunate that the value of the "big inch", both as an artery of war transportation and as an outstanding accomplishment of the engineer, need not be kept secret in the interest of national security. It is equally fortunate that its value can be repeatedly appreciated in the news of Allied victories in the air, at sea, and wherever the mechanized forces roll forward, powered and lubricated with American oil—oil that the "big inch" helped deliver faster.

Because the War Emergency Pipeline is a great idea brought to functioning reality by the energy and skill and patriotic enthusiasm of the pipe-line engineers of the American petroleum industry, I am doubly privileged and proud to be able to express here both official and personal recognition and gratitude for the job they have done.

The "big inch" is more than a reflection—a living, working reflection—of engineering skill and practical imagination. It is an operating symbol of engineering foresight and professional enthusiasm. For the pipe line was crystallized in blue prints, bills of material, and specifications long before final approval for its construction could be procured. It was "slide-ruled" to actuality and long off the drafting boards while it was, in terms of logistics, still just a fighting gleam in Petroleum Administrator Ickes' eye.

But the pipe-line engineers who enlisted early to design the War Emergency Pipeline didn't wait. They detailed the construction plans down to the last valve fitting—and they were ready.

The job they did took a special brand of faith—a sense of the same "big inch" war urgency, I believe, that prompted their companies to permit them leave from their regular important and exacting posts to get the work done. Something more, I believe, than merely the desire to be in on the creation of the great oil jugular of the United Nations spurred "Cap" Finney and his colleagues.

They spent themselves and their time. Their companies spent thousands of dollars. And why? To build another sinew of security for this Nation; without profit and with little enough glory for themselves.

They did the job. It was gruelling and difficult. Only another engineer can know what satisfactions may have simmered up through the long hours they spent designing the "big inch". But all the men of America's petroleum industry can salute their efforts as among the finest in the whole spectrum of the war accomplishments of America's engineers.

W. R. FINNEY, *Chairman*
CHARLES BUNJE, JR.
G. J. HANKS
BURT E. HULL
C. H. KOUNTZ
T. E. SWIGART

These men, the members of Temporary Joint Pipeline Engineering Subcommittee, created pursuant to a recommendation of Petroleum Administrator (then Coördinator) for War Harold L. Ickes, engineered the War Emergency Pipeline. To them, and to hundreds of their unsung colleagues who designed the world's greatest petroleum pipe line—a humble salute. ☆☆☆

Pipe Line

P 615.

The "Big Inch" Timetable

PETROLEUM ENGINEER Exclusive Feature

☆ A discussion of developments preliminary to actual construction of the line

A YEAR and a half before Pearl Harbor the oil and pipe-line companies were alert to the expanding need for deliveries of crude oil to refineries in the Eastern Seaboard. The impact of foreign war developments still left the average citizen cold to the lowering prospects but stimulated initial oil industry action that resulted in an increase of crude oil movements to the East by pipe line from approximately 20,000 bbl. per day to 65,000 bbl. per day. That action took the form of recalling to service certain idle pipe-line facilities that were suitable for rehabilitation, and while the prospect of a great, major pipe line from Texas to the East Coast was still only a fit subject for pullman car speculations, this action may be considered as the point of origin for the chain of developments that led ultimately to the planning, design, and construction of the 24-in. War Emergency Pipeline.

The intrinsic origin lay in the vision and practical foresight of Petroleum Administrator for War Harold L. Ickes, who, at about that time, offered himself up to the wrath and ridicule of a less-informed and more short-sighted multitude within and without the petroleum industry by suggesting, in a report to President Roosevelt on the East Coast's prospects for a continuing adequate oil supply, that the exigencies of war could make a big Texas-East Coast pipe line a war necessity.

Possibilities Investigated

In May, 1941, investigations regarding the practical possibilities of such a pine line or pipe lines were undertaken and led directly to a conference of oil company representatives who forthwith authorized a special group of pipeline engineers to select a route, make the necessary aerial surveys and ground reconnaissance, and to design a 24-in.

The line descends a hill and fades from view into the distant horizon

pipe line that would run from East Texas to refinery centers at New York and Philadelphia.

Coincident with these developments, President Roosevelt appointed Secretary Ickes to the new national defense post of Petroleum Coördinator for War, and the stage was set for a coöperative, multiple attack on the developing problem of threatened East Coast petroleum shortage.

On September 5, 1941, the principal oil companies operating in the East organized National Defense Pipelines, Inc., and proposed the construction of the pipe line with private capital.

During the later half of 1941 petroleum industry committees, appointed by the Petroleum Coördinator, carried the planning and design of the "Big Inch" forward to the point where formal application to the Supplies Priorities and Allocations Board for allocations of the requisite materials could be made on the dual basis of national need and the facts and figures that would show how and with what the pipe line could be built. The application was denied on October 2, 1941.

The "potential" petroleum shortage in the East had yet to hit home; to overtake civilian and industrial consumers of petroleum and petroleum products throughout the East with the authority of actual inconvenience.

By March, 1942, the outlines of the developing shortage situation were clarified to the point where not one or even two new pipe lines to the East, but the reorganization of many pipeline facilities, became an apparent necessity. A large part of the American tanker fleet normally employed in transporting petroleum and petroleum products to the Atlantic Seaboard area had been diverted to other war-essential duty; others had been sunk. The shortage of transportation that *is* the oil shortage called for new, positive action. The action was forthcoming in a request embodied in Recommendation No. 49 of the Office of Petroleum Coördinator for War, that the Petroleum Industry War Council formulate "concrete and specific plans to provide additional pipe-line capacity to serve the shortage area and by such means as might be necessary, including construction, reconstruction, relocation, expansion, extension, conversion, and reversal, to increase the capacity and efficiency of existing pipe lines in the shortage area and in areas tributary thereto."

This recommendation formalized for action an initial set of proposals for the construction, conversion, reversal, and other adjustment of numerous pipe-line facilities already thrashed out and agreed to by probably the greatest aggregation of pipe-line engineers, oil transportation experts, and economists ever to gather under one roof for the determination of joint responsibilities and actions.

"Big Inch" origin lay in the vision and practical foresight of Petroleum Administrator for War Harold L. Ickes

". . . to the strong men without whose loyal and patriotic services the line could not have been built, I say: You have your country's congratulations for a job well done."

At the call of the Engineering Subcommittee, representatives of 67 separate companies engaged in the pipe-line transportation of crude oil or petroleum products had met at Tulsa, Oklahoma. From March 23 through the 26th they had wrestled with the complicated problem of so organizing and integrating the use of their respective pipe lines that critically needed oil supplies could move in heavier volume than ever before toward the East.

Proposals

To the famous Tulsa meeting more than 112 individual companies had been invited. The 67 that were actually represented by acceptance of the invitation came up with the following proposals:

Project 1. To increase by 25,000 bbl. per day the movement of crude oil from Texas north and east through existing pipe-line systems by means of the installation of additional pumping units, loop lines and the reversal of the Tuscarora pipe line.

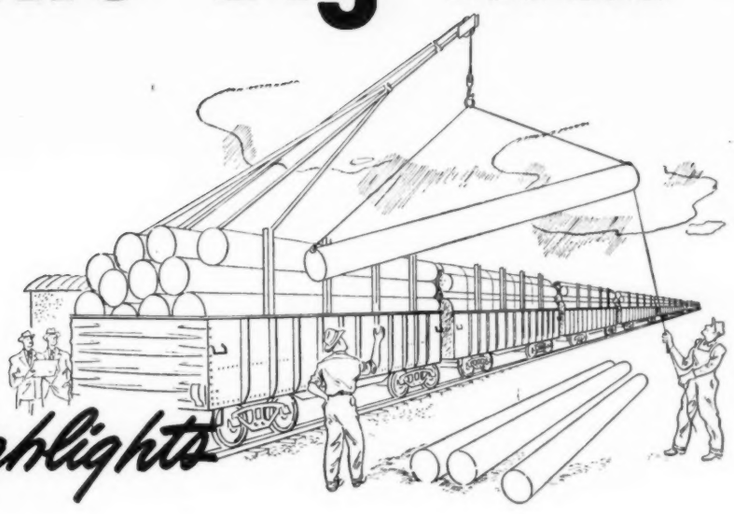
Project 2. The Plantation Pipeline Project: (1) The construction of a 60,000-bbl.-per-day pipe line from the vicinity of Beaumont, Texas, to Baton Rouge, Louisiana, to supply the Plantation Pipeline. (2) The expansion of the capacity of the Plantation Pipeline by installing intermediate pumping stations. (3) The extension of the Plantation Pipeline from Greensboro, North Carolina, to a point in Virginia, northwest of Norfolk.

(Continued on Page 112)

The REAL FACTS

1. THE WORLD'S LARGEST OIL LINE.
2. TOTAL LENGTH MAIN LINE 24-INCH PIPE...1272 Miles.
3. 24-INCH SEAMLESS PIPE FURNISHED BY NATIONAL TUBE COMPANY...1192 Miles.
4. 24-INCH PIPE FURNISHED BY OTHERS . . . 80 Miles.
5. WALL THICKNESS OF SEAMLESS PIPE...⅜ Inch, ends of pipe beveled for welding.
6. GRADE OF MATERIAL . . . Open Hearth Steel — A.P.I. Grade B Specifications.
7. EVERY SINGLE LENGTH, 70,000 in the first unit, hydrostatically tested far in excess of working pressure, without a single failure.
8. AVERAGE LENGTHS SHIPPED . . . 41 feet.
9. PIPE FOR FIRST UNIT...550 Miles . . . finished exactly on schedule.
10. THE ORDER WAS COMPLETED in record-breaking time of 124 days.
11. MILLS OF NATIONAL TUBE COMPANY were the only ones in America big enough and fast enough to produce the Seamless Pipe for this job.
12. CAPACITY OF LINE . . . 300,000 barrels per day.

about the "Big-inch" line!



"Big-inch" highlights

WHEN this new oil line first got under way, everybody tried to name it. Washington called it the War Emergency Pipe Line. Others suggested Victory Pipe Line, and still others, Texas to New York Pipe Line. But when old timers, who were accustomed to tossing 8-inch and 10-inch pipe around, first spotted this 24-inch pipe, they were left dazed and over-awed. Someone started calling it "Big-Inch" . . . and the name stuck.

"Big-Inch" brought with it big problems. The nation's pipe makers were heavily engaged in other war work. Could 550 miles of 24-inch diameter pipe be produced in four months? NATIONAL Tube Company agreed to do the job alone—and to furnish *seamless* pipe. Although NATIONAL was already making millions of bombs and shells, and millions of feet of aircraft tubing, as well as thousands of miles of vital pipe and tubing for other important purposes—the order was completed on time.

By then the second unit had been approved. Our mills never stopped rolling. Now they are well on the way toward turning out 642 more miles of the same "Big-Inch" pipe for the second unit.

Naturally, we are proud of this achievement. Our part, making the pipe, plus the remarkable job of the contractors, laying the line, adds up to one of the biggest engineering feats of modern times—an important contribution to our Country's war effort to speed the day of Victory!

NATIONAL TUBE COMPANY

PITTSBURGH, PA.

United States Steel Export Company, New York

NATIONAL SEAMLESS

UNITED STATES STEEL

The pipe joint is lined-up and the welding clamp applied

(Continued from Page 109)

Project 3. The construction of a 15,000-bbl.-per-day products line from Fostoria, Ohio, connecting the Shell and Sohio gasoline pipe lines with the Sun - Susquehanna system at Akron, Ohio, for the movement of petroleum products eastward.

Project 4. The reversal of the Keystone-Atlantic gasoline pipe line and an increase in the movement through the Socony-Vacuum pipe line from Buffalo, New York, to feed the Sun pipe line going south.

Project 5. (1) The reconditioning, rearrangement, and conversion of a crude oil pipe line or pipe lines between Port Arthur, Texas, and El Dorado, Arkansas, into a products pipe line or pipe lines: the reversal of such pipe line or pipe lines, and their extension. (2) The reversal of an 8-in. products pipe line between Shreveport, Louisiana, and Port Arthur, Texas, to move products to Shreveport. (3) The construction of a 150-mile 10-in. products pipe line from El Dorado, Arkansas, to Helena, Arkansas.

Project 6. The construction of a new 20-in. crude oil pipe line from East Texas to Salem, Illinois, to move 200,000 bbl. per day. (Involving construction of tankage, loading racks, and a barge terminal on the Ohio River.)

Project 7. (1) The conversion and reversal of a 12-in. crude oil pipe line extending from East Texas to Houston in order to deliver 60,000 bbl. per day of refined petroleum products from the Houston refineries to a point in or near the East Texas field. (2) The construction of a 12-in. and a 14-in. pipe line from the East Texas field or its vicinity to deliver 75,000 bbl. per day of refined petroleum products to a point near Paducah, Kentucky.

Project 8. The construction of a 24-in. crude oil pipe line from East Texas to Salem, Illinois, with a capacity of 300,000 bbl. per day and the extension of this line eastward to the refineries of the New York and Philadelphia areas to deliver 250,000 bbl. per day of crude oil.

Project 9. The conversion of the 20-in. pipe line described under Project 6 to a products line and the exension of this line to a point in western Pennsylvania for connection with existing pipe lines or the extension of the line farther east.

"Big Inch" Project

The "Big Inch" as originally proposed was simply "Project 8" in the catalog of evolution for a key group of pipe lines whose service could be created or adjusted to save the East Coast from a serious oil famine.

This segment of the report of the Tulsa meeting is reproduced here to provide the reader with some "Monday-morning" perspective on the pipe-line program as it has evolved during the last 12 months.

On April 7, 1942, in Washington, the Petroleum Industry War Council met and approved, with the exception of the 20-in. line for products, all recommendations of the Tulsa conferees. Simultaneously the oil companies agreed to go ahead with the projects involving second-hand pipe and pumping equipment, and the war-evolution of petroleum transportation by pipe line was under way.

On June 10, 1942, the War Production Board approved construction of the Texas-Illinois leg of the 24-in. War Emergency Pipeline.

On June 19, 1942, War Emergency Pipelines, Inc., was organized, and 44 days later the first of the "Big Inch" pipe line was laid.

On October 26, 1942, allocation of steel for the construction of the War Emergency Pipeline through to its logical eastern termini at New York and Philadelphia was approved by WPB.

On February 19, 1943—just 200 days from the start of actual construction—the first "Big Inch" oil was pumped from Tank No. 1 at the Norris City, Illinois, terminal. That night it started east, consigned to Gulf at Philadelphia. En route it rolled close to the 857-mile right-of-way of the extension where Texas and Oklahoma pipeliners cuss the Yankee winter and work doggedly through every daylight hour, when alternate thaws and blizzards permit, to punch the big line through on schedule—June!

—— ☆ ☆ ☆ ——

Making a river crossing. Extremes in weather have been experienced during the line's construction

Phases of "Big Inch" Engineering

PETROLEUM ENGINEER Exclusive Feature

☆ **Careful planning of the line facilitates construction**

by W. R. Finney

Chairman, Temporary Joint Pipeline Engineering Subcommittee

ALTHOUGH dwindling petroleum supplies and an increasing curtailment of the normal ocean tanker methods of maintaining an adequate flow of petroleum products to the Eastern Seaboard defined the oil shortage problem decisively, and was ultimately responsible for relative unanimity of opinion with respect to the necessity for a "Big Inch" pipe line from Texas to the East, a considerable diversity of opinion with respect to construction plans, practices, and materials reigned with reference to the 24-in. pipe line itself.

At the outset numerous suggestions were received by PAW and the industry engineers, supporting the use of materials other than steel for the construction of the line.

W. R. FINNEY

The principal substitutes proposed were: Reinforced concrete pipe, asbestos cement pipe, wood fiber and cotton, and vitrified tile and glass.

All were rejected.

Reinforced concrete pressure pipe, although standard material for the construction of long distance water pipeline systems, was determined to be unsuitable for use at the operating pressures required for the 24-in. line. It was found also that concrete pipe of dimensions and pressure rating suitable to sustain a flow of 300,000 bbl. per day was not currently in commercial produc-

(Continued on Page 116)

OIL FOR THE

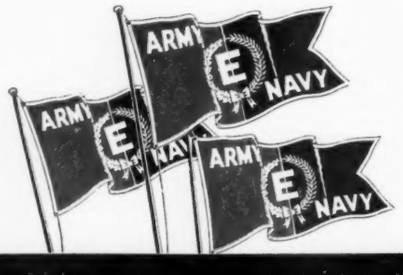
THROUGH THE WORLD'S LARGEST AND MOST DRAMATIC PIPE LINE

August, 1942, marked the beginning of one of the really big engineering projects needed to win this war . . . a 24-inch pipe line to bring precious oil to the Eastern Seaboard...a rush against time...a two-fisted blow at the axis.

Yes, a great feat and in a hurry . . . the largest pipe line in the world, planned and built by men who know more about pipe lines than anyone in the world. The first 531 miles of the War Emergency Pipe Line is practically completed—so now on to the next 812 mile stretch to the seaboard!

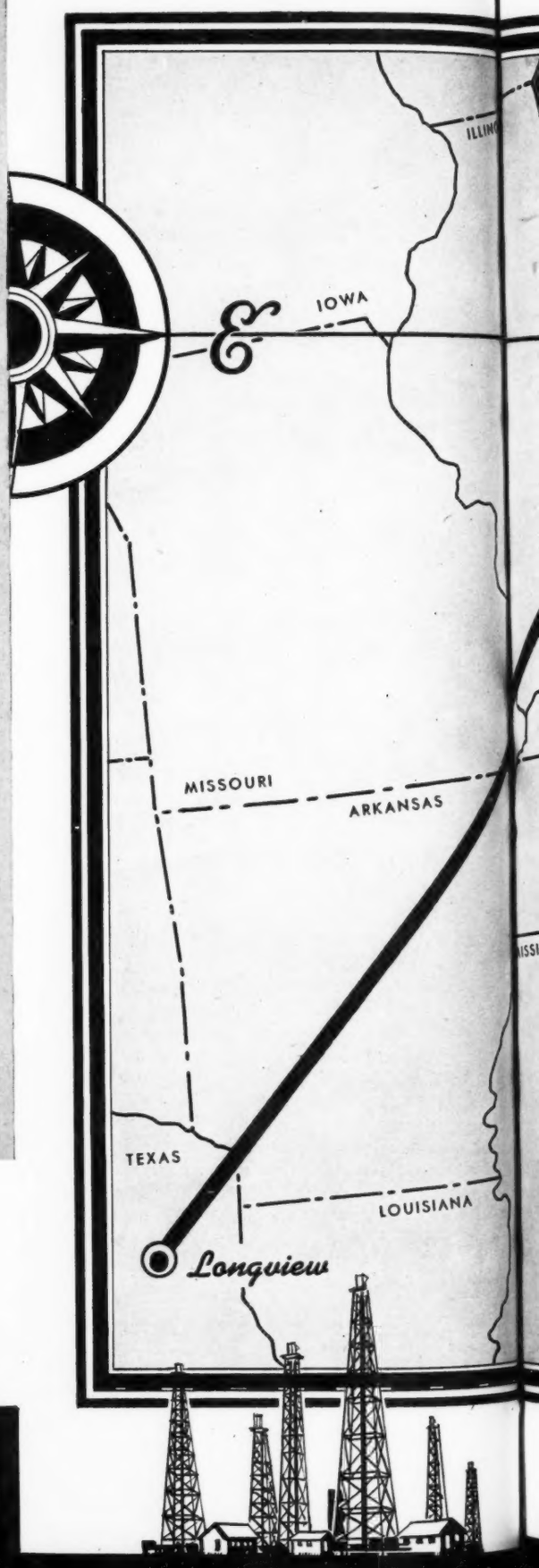
Such a pipe line needs bigger pumps than have ever been used before for such service. Ingersoll-Rand is proud that its Cameron Division was called upon to develop new pumps for the line . . . proud that in the first 531 miles there are 10 large 1500 hp Cameron Centrifugal Pumps . . . prouder still that there will be 26 more of these units in the remaining 812 miles of line.

Ingersoll-Rand Compressors and Pumps and Engines are serving all divisions of the petroleum industry—refining, aviation gasoline, synthetic rubber, recycling, repressuring, pipe lines, bulk stations. And Ingersoll-Rand Portables and Air Tools helped build the Big Inch Line.



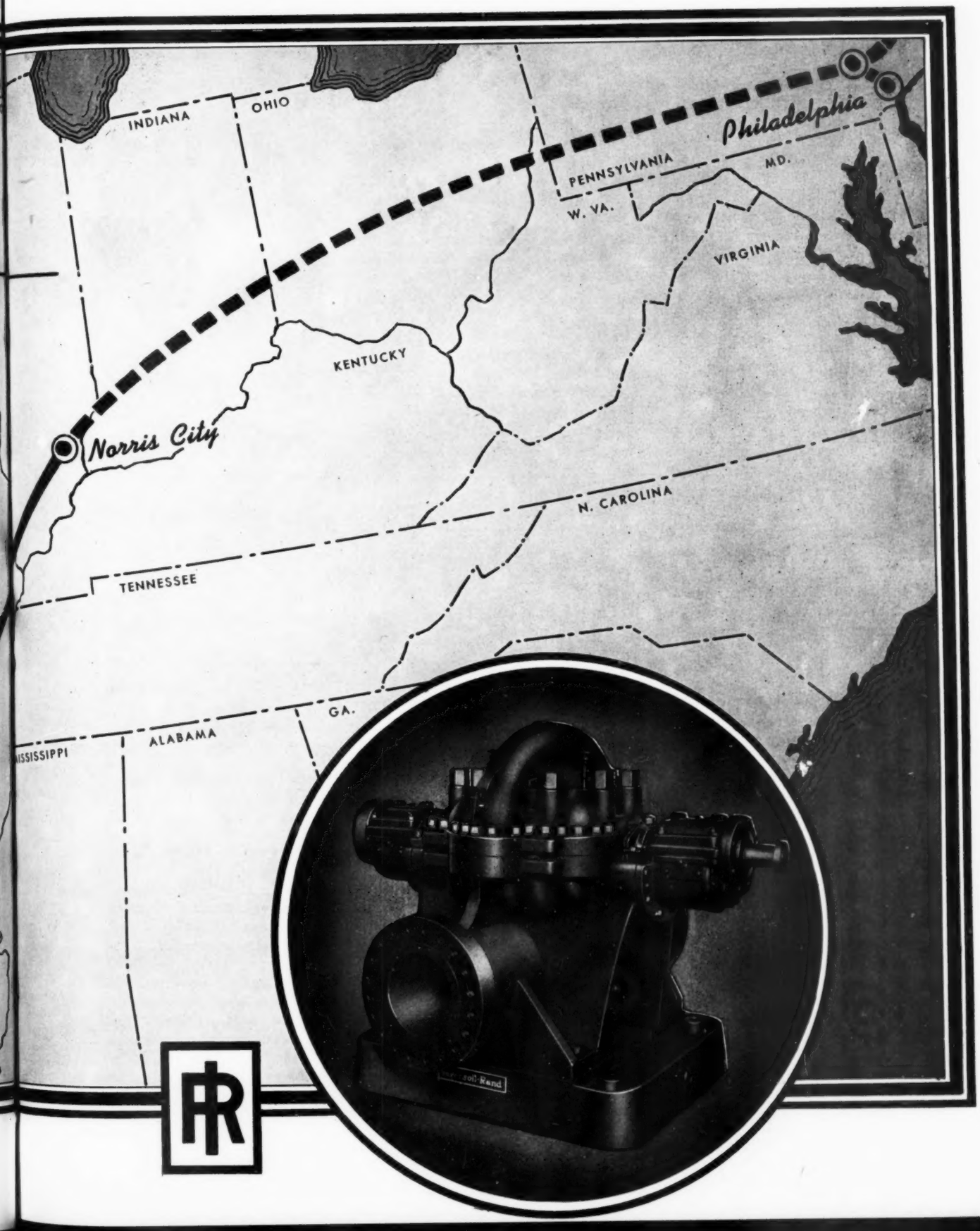
All plants of Ingersoll-Rand Company are flying the Army-Navy "E" awarded "for high achievement in the production of war materials."

10-238



11 BROADWAY, NEW YORK, N.Y.

EAST !


INDIANA
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GA.
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ISSISSIPPI
Ingersoll-Rand

Pipe Line

To those who guide the construction of the "big inch" . . .

A statement by

W. Alton Jones

President, War Emergency Pipelines, Inc.

W. ALTON JONES

HE occupies a unique and enviable position in the structure of American accomplishment. Professionally, he stands between the originator and the builder—the key man in the process of putting blood and muscle—usefulness—into an idea. Practically, he is the man who contributes, in large measure, to the strength and vitality of industry, and through industry, to the strength and vitality of the nation. Historically, his skill, judgment, and imagination have helped to make this country great. Today he is guiding the construction of the "Big Inch," another service structure that will serve this nation as effectively as any he has ever designed.

I would be the last to minimize the tremendous contributions of other men, professions, and crafts to the construction of this great new artery for oil, but to the extent that the War Emergency Pipeline already is, and shall increasingly become, a direct fighting tool in the total armament of the United Nations—to the pipe-line engineers must go a major share of the credit. For more than half a century they have planned and built the underground arteries of petroleum transportation that have been so vital to the rapid growth and high efficiency of the oil industry. Today, at the doomsday juncture in our advancing civilization, they have scored a new high in achievement and service to their country with the War Emergency Pipeline.

On the final balance sheet of the petroleum industry's role in the victory we are all endeavoring to forge fast and decisively, the engineering-construction of the "Big Inch" will stand high. The role the pipe-line engineers and builders have played between the origination of the "Big Inch" idea by Petroleum Administrator for War Harold L. Ickes and the peace with victory that "Big Inch" oil will help so mightily to secure, outspeaks any praise my words could fashion.

(Continued from Page 113)

tion, and that manufacturing plants, if installed for the production of the requisite 1,120,000 tons, would require an undue expenditure of both critical time and 7500 tons of steel. Moreover, as the conventional reinforced concrete pipe calls for from 55 to 60 percent as much steel as a conventional steel pipe line, the use of this critical material would therefore not have been eliminated. The necessary use of 1,200,000 bbl. of cement and 230 tons of synthetic rubber, as well as the grave doubt that the necessary pipe couplings required in a concrete line of this construction could be made sufficiently tight and lasting for an oil pipe line under the "Big Inch" operating conditions, likewise precluded serious consideration of this material for the pipe.

The objections to the use of asbestos cement steel-lined pipe were, in general, based on the same limitations that eliminated reinforced concrete pipe from consideration for the "Big Inch." No previous experience with this type of pipe for high-pressure oil lines was available. It is actually a thin-wall steel pipe with working pressures approximately 50 percent of those of modern oil pipe lines. It cannot be bent and is therefore poorly suited to the construction practices used in building the 24-in. facility. It was determined moreover that, considering the pipe steel required for the projected length of the pipe line plus the more than half a million couplings and the million-plus synthetic rubber gasket rings required, no appreciable saving in critical materials would result from this type construction.

During the considerations of alternate pipe materials it came to the attention of the Petroleum Coördinator that Russian engineers were experimenting with a pipe line made of wood fiber and cotton. Insufficient data regarding this development made its consideration impracticable.

The proponents of a vitrified tile and glass pipe line were generally persons wholly unfamiliar with the operating characteristics of oil pipe lines. The obvious facts that these materials are wholly unsuited to the pressures and tightness demands of an oil pipe line eliminated vitrified tile and glass from further consideration as a suitable pipe material.

Steel, and preferably seamless steel, was the obvious and final choice.

Not only with respect to its strength, permanence, and relative ease of handling in construction, was steel determined to be the best material for "Big Inch" pipe. During the course of the long analysis of petroleum supply and transportation needs of the nation and particularly, of course, the Eastern Seaboard area, it was determined that the use of steel in a pipe line compared very favorably in terms of actual deliveries of oil with the use of steel in the con-

BEARINGS *THAT HELPED BRING OIL EAST*

● *Built by* CARDWELL MFG. CO.

From this Model PO Sideboom that lowered it to its resting place to the pumps that keep oil flowing freely through it, the "Big Inch" Pipeline has depended upon SKF Bearings. As this line stretched across the states, SKF Bearings worked tirelessly on the moving parts of busy machines . . . holding each in proper alignment . . . avoiding bearing trouble . . . maintaining close tolerances . . . never needing adjustments. And thus, again, SKF-equipped machines have proved their ability to lick a tough job on the home front just as other SKF-equipped machines are licking tough jobs on the fighting fronts. 5284

SKF INDUSTRIES, INC., PHILA., PA.

Tips
ON BEARING CARE
To make present equipment last longer
1. Use clean lubricant recommended by the manufacturer of this machine.
2. Avoid loads and speeds beyond those recommended by the manufacturer.
3. If necessary to remove bearings, keep them properly lubricated. Avoid the intrusion of water and dirt. Apply pressure on the inner race only. Don't hammer outer race.
SKF
BALL AND ROLLER
BEARINGS

Cleaning and priming the pipe—a single operation

struction of alternate transportation media. It was found that a pipe line of the length and dimensions proposed for the "Big Inch" would have a higher efficiency rating than would either barges or tank cars required for an equivalent delivery of oil to the East. On the basis of a normal turn-around operation of ocean tankers along the base route—Port Arthur, Texas, to New York—tankers were estimated to be approximately 60 percent more efficient in the use of steel. Calculated, however, on the basis of war-time operation involving a substantial lengthening of the normal turn-around time, the relative efficiencies of steel for the "Big Inch" and for the construction of new tanker facilities capable of maintaining an equivalent delivery of oil to the East, were practically equal.

Tapered Principle Abandoned

Once it was determined that seamless steel pipe should be used and could be obtained for the construction of the

Although each joint of pipe weighs approximately two tons, clamps are added when the river to be crossed is wide and swift

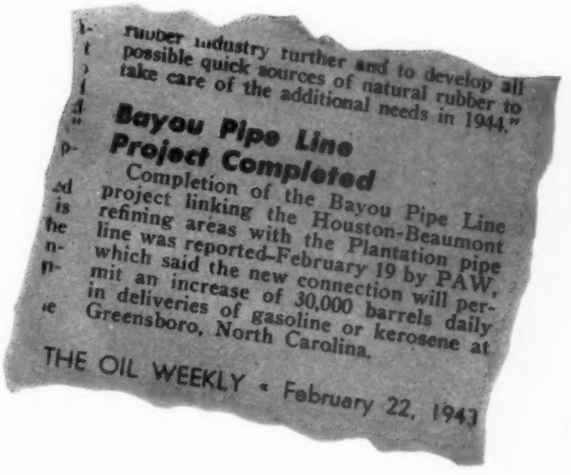
NEVER TOO LITTLE!
NEVER TOO LATE!

Again, GULF STATES Delivers On Time!

The Bayou Pipe Line System from Baytown to Baton Rouge is using electric power throughout for its pumping requirements. Nine of the eleven pump stations are served direct by Gulf States Utilities Company and another is served indirectly.

This system, which ties in with the Plantation Pipe Line System at Baton Rouge, connects the refinery areas of the Houston and Sabine districts to the Eastern seaboard. The Plantation Pipe Line now extends from Baton Rouge, Louisiana, to Greensboro, North Carolina, and will be extended to Richmond, Virginia.

Gulf States Utilities Company also furnishes electric power to the terminal station of the Plantation Pipe Line System.

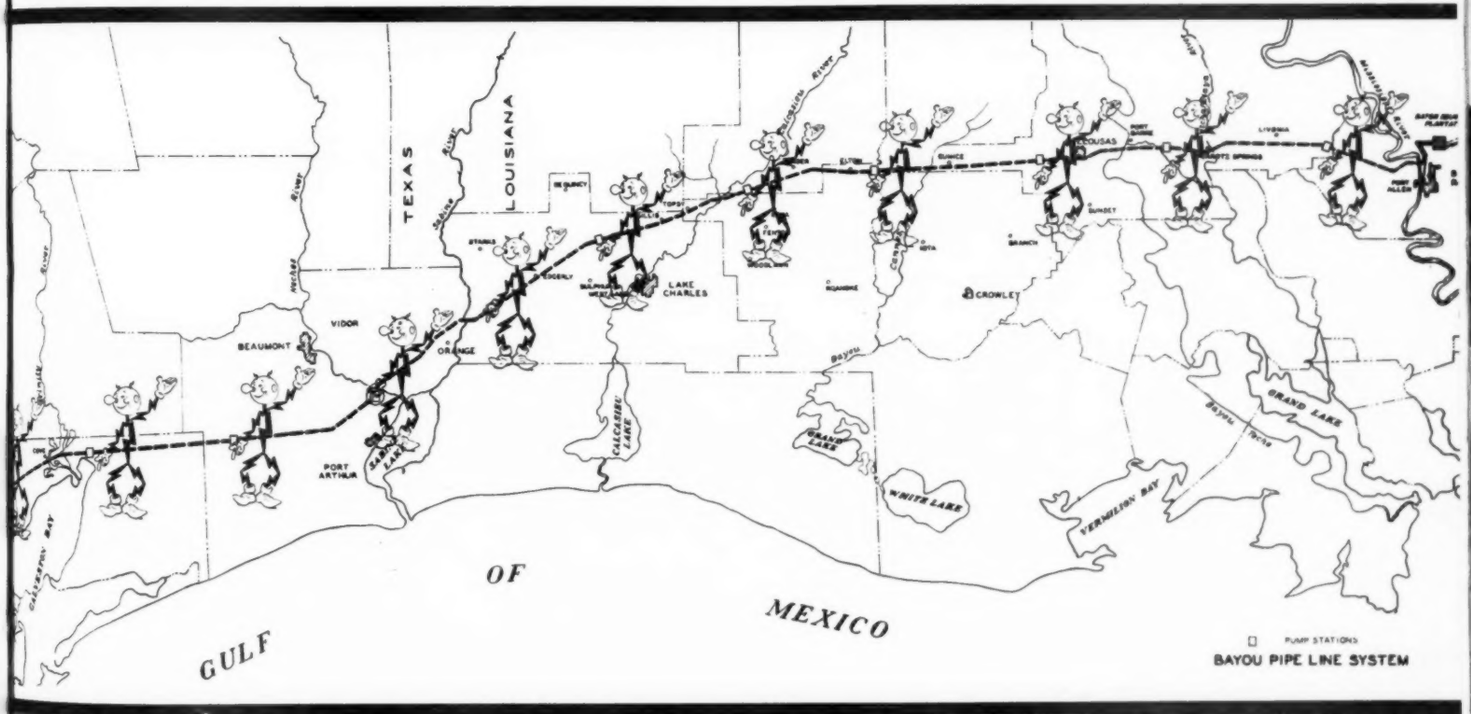


rubber industry further and to develop all possible quick sources of natural rubber to take care of the additional needs in 1944."

Bayou Pipe Line Project Completed

Completion of the Bayou Pipe Line project linking the Houston-Beaumont refining areas with the Plantation pipe line was reported February 19 by PAW, which said the new connection will permit an increase of 30,000 barrels daily in deliveries of gasoline or kerosene at Greensboro, North Carolina.

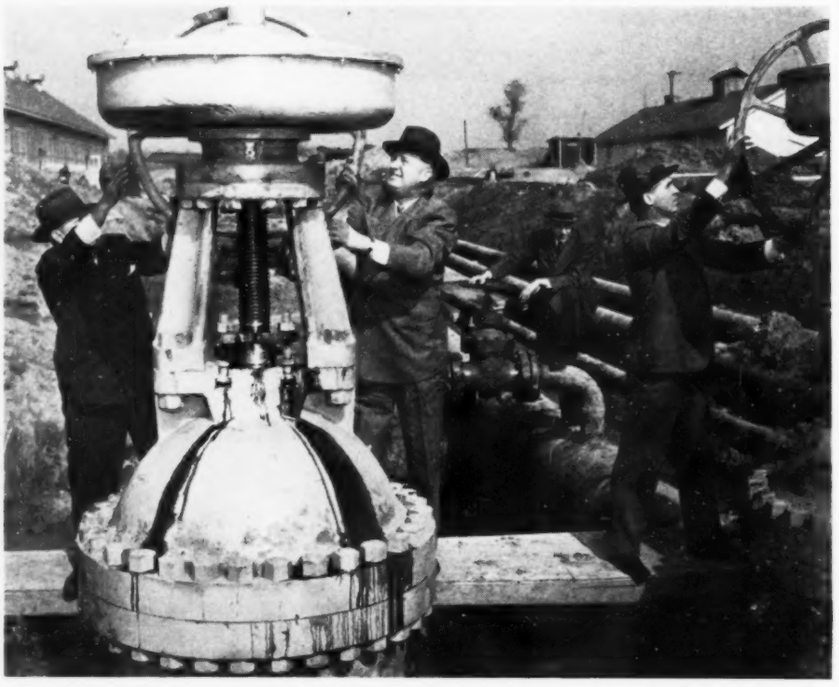
THE OIL WEEKLY • February 22, 1943



GULF STATES UTILITIES CO.

General Offices: **Beaumont, Texas, Lake Charles and Baton Rouge, Louisiana**

DEPENDABLE GULF STATES UTILITIES CO. PUBLIC SERVICE



Opening the valves at one of the stations are Burt Hull, W. Alton Jones, Ralph Davies, and George A. Hill, Jr.

initial Longview to Southern Illinois leg of the line, the determination that the "Big Inch" should be of welded construction throughout was a foregone conclusion. The engineers recommended that the pipe conform to A.P.I., Grade B, specifications, which are based on steel having an ultimate tensile strength of 60,000 lb. per sq. in.

The original plans contemplated the so-called "tapered" principle of pipeline design. This is based on diminishing the pipe wall thickness in accordance with the decline of internal fluid pressure from one pump station to the next. A material saving in the required amount of steel was contemplated, but in actual construction this economy was foregone in the interest of assured permanence, and because of the added construction problems involved in following the "tapered" principle in the multiple-spread construction practice followed. All "Big Inch" pipe, with the exception of that installed at river crossings, where the pipe is heavier, is of $\frac{3}{8}$-in. wall thickness.

An additional factor, basic to the change in original plans for tapering the wall thickness of the pipe between pump stations, was the consideration that at some future date intermediate pump stations, which might be installed for the purpose of increasing total throughput, could be installed for materially higher working pressures than would otherwise have been possible.

Two welders working on the same joint of pipe

Tankage Requirements

The tankage required for efficient operation of the Texas-Illinois segment of the pipe line calls for a storage capacity of 3,750,000 bbl. All tanks have been obtained by the dismantling, reconditioning, and re-erection of existing facilities. Although the use of second-hand tankage has permitted no substantial economy in money, the reduction of the amount of new steel that might otherwise have been required, has been enormous.

Pumping Facilities

Total power requirements for pumping crude oil through the "Big Inch" from East Texas to Phoenixville, Pennsylvania, and thence through the 20-in. pipe-line branches to New York and Philadelphia are 86,000 b.hp. The total number of individual pump stations that will be installed when the line is completed by midsummer 1943 is 25.

Cost of Line

Original estimates of cost for the full Texas-East Coast War Emergency Pipeline have proved essentially exact.

Main and branch pipe lines, including pump stations, were estimated at $87,000,000. Terminal tankage was estimated at $8,000,000. The total, $95,000,000, will be, despite the changes in many price factors that have occurred since the initiation of the line, substantially the figure financed by the Defense Plant Corporation on completion of the line.

The line-fill column of oil will run to approximately $5,000,000, making the full "Big Inch" approximately an even $100,000,000 war project.

☆ ☆ ☆

A coating and wrapping machine negotiates a sag bend

"Big Inch" Construction Features

PETROLEUM ENGINEER Exclusive Feature

☆ Difficult problems solved in laying first segment of project

By Special Correspondent for *The Petroleum Engineer* (as gleaned from field trips and discussions with Burt E. Hull, vice-president and general manager; A. N. Horne, vice-president, and Oscar Wolfe, chief engineer, War Emergency Pipelines, Inc.)

MANY unusual problems confronted the engineers of the "Big Inch" when they bent to the drafting boards and calloused their fingers with interminable slip-stick calculations, and although the pipeliners of the construction crews would be prone to dwell on the difficulties and problems that they too had to meet in putting the "Big Inch" to bed, actual construction practice and operations were essentially those customary to all modern pipe-line construction.

The more than 180,000 joints of steel pipe that will be required to build the 1255-mile main 24-in. pipe line and the 20-in branches, has moved, or is moving, today from the steel mills to selected unloading points along the right-of-way and from there delivered by stringing trucks and tractors in the usual manner. Some of the stringing contractors have found it advisable to redesign their equipment for easier handling of the heavier pipe. Many a skilled driver of the big "cats" has been dumped from his seat by the tricky maneuverings of the almost two-ton, 40-ft. joints; but in general the job has gone forward at a pace of approximately 50 carloads or 4 to 5 miles of pipe delivered and strung daily.

Along the four and a half million rods traversed by the "Big Inch" right-of-way, construction crews have had to conquer every imaginable kind of going. Men, mules, and equipment have bogged down on occasion in the river bottomlands of lower Arkansas and elsewhere. Pipe gangs, welding crews, "cat" operators—all the pipeliners from field superintendents down—have cussed the rock, the rubble, and the ditches that wouldn't stand up, in all nine states through which the big line lies today or will lie before midsummer. Despite all the hazards and difficulties, right-of-way clearing has progressed rapidly at all times, well in advance of the construction crews. The streamlined progression of the work from staking to backfill has moved ahead at the fastest pace ever achieved for an undertaking of comparable magnitude.

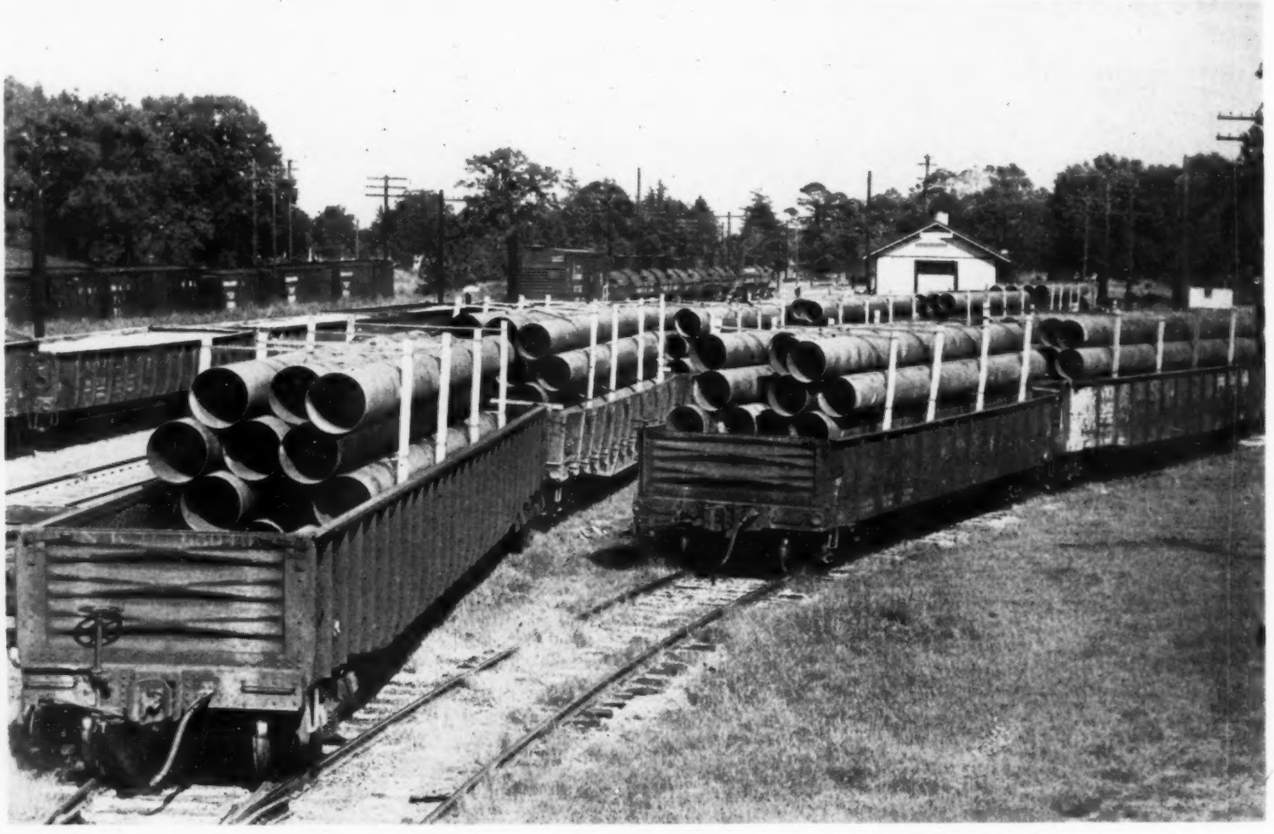
Qualified observers have called the clearing of the "Big Inch" right-of-way as big a job as the blazing of the route of the Alcan Highway to Alaska.

Ditching and Welding

Excavating the ditch required all the equipment from giant ditching machines to hand shovels and the canny skill of the pneumatic hammer operators and powder monkeys.

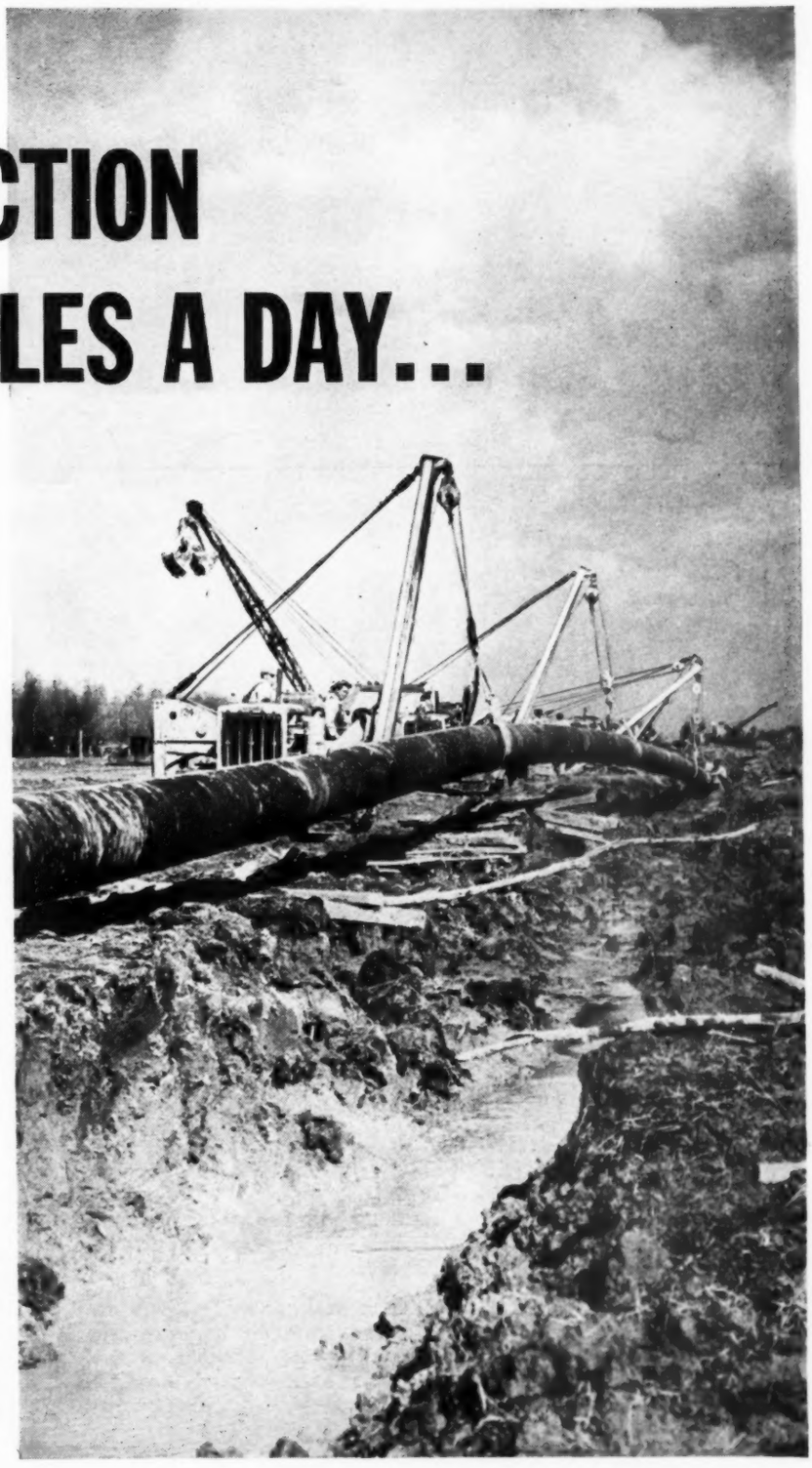
The ditch was dug to a specified depth of 48 in. by 36 in.

Carloads of pipe at one of the many destination points ready to be strung



PROTECTION AT 5 MILES A DAY...

for world's fastest-built pipeline



The close cooperation of contractors and engineers of War Emergency Pipelines, Inc., and Barrett Field Service men has made possible new records for speed in the construction of the world's largest capacity oil line and in the protection of that line with Barrett Enamel.

Such record-breaking speed would have been impossible without the use of a protective coating which could be applied quickly and easily in all kinds of weather. Barrett Enamel answers this requirement and more. It also provides superior resistance to the corrosion of soil acids, alkalis and electrolysis.

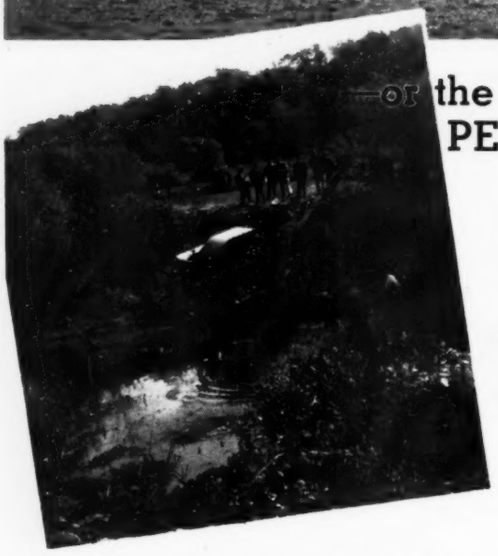
Engineers knew they could depend upon Barrett Enamel to withstand the unusual underground stresses that will occur in this line, transversing as it does, all kinds of terrain and all kinds of soil—mountains, plains, swamps and woodland.

This great new emergency oil artery, which is to serve America for years to come, had to be handled with utmost speed in laying. In any emergency where high protection and speed are necessities, Barrett Enamel meets requirements at the lowest possible cost.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK

Barrett PIPELINE ENAMEL

FIELD SERVICE—Our Pipeline Service Department and staff of Field Service men are equipped to provide both technical and on-the-job assistance in the use of Barrett Enamel.



—or the Mountains of
PENNSYLVANIA!

Tough Terrain

Never Stops a

WHITAKER PIPE LINE CREW

SPEED AND DEPENDABILITY are foremost requirements for pipeline contractors entrusted with the job of rushing the War Emergency big-inch pipeline through to the Eastern seaboard—for every day saved brings Victory that much nearer.

THE ENTIRE WHITAKER ORGANIZATION is justly proud of the confidence which WEP, Inc. expressed by awarding this company one of the toughest sections of this final 857-mile extension—across the rock-ribbed mountains and boggy ravines of Pennsylvania.

TO WHITAKER MEN, even such assignments as this are "history". With the latest methods and equipment—plus the "know how" and experience from working in this terrain before—they are well prepared to push any job through with record-breaking speed.

For Dependable Pipe Line Service, Consult

O. C. WHITAKER CO.

Pipe Line and Electric Welding Contractors for New Construction, Reconditioning and Taking Up Old Lines

General Offices:
806 Dan Waggoner Bldg.,
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HOUSTON, TEXAS

OVER 20 YEARS CONTINUOUS PIPE LINE EXPERIENCE

Along a large part of the route the ditch was dug to the specified depth and width, 48 in. by 36 in., by a single ditching machine. Through some country a faster and more economical job could be done by a tandem ditching operation. One ditching wheel was used to cut out the top half of the ditch and 36-in. buckets were used to complete the job.

Depending upon soil conditions, ditching frequently was done well in advance of the pipe and welding gangs. Inevitably, however, these workers followed quite closely on the heels of the ditching equipment.

"Big Inch" welding was done by either of two methods, and the selection of the method was based on the skill of the welders available in the contractors' working spread, the preference of the contractor himself, and was subject in all cases to the final approval of the "Big Inch" field generals, Burt Hall, Al Horne, Oscar Burden, and their spread inspectors.

Stove-pipe welding, in which the progress of the line is made joint by joint, was preferred and used by some of the welding gangs. Others used the roll-welding method, which involves the welding-up of several joints of pipe into a section and its subsequent "tie-in" to the line.

Coating and Wrapping

All 531 miles of the line from Longview, Texas, to Norris City, Illinois, was primed, then coated with coal tar enamel, and wrapped with a heavy layer of asbestos felt. The eastern extension of the War Emergency Pipeline will, according to data available at this time, be coated only through areas known to be "hot" and at all river and stream crossings.

Priming, coating, and wrapping are primarily a machine operation. A combination pipe-cleaning and priming machine is self-propelled along the pipe. A series of spinning brushes removes all rust, mill scale, and other field contamination. The coal tar primer is thoroughly applied through a 360° application mechanism, with primer thickness controlled by the application temperature of the primer material. The speed of drying varies with temperature and weather conditions of the atmosphere and the primer coat forms a chemical-physical bond between the steel surface of the pipe and the heavy coat of coal tar enamel that is subsequently applied in the same manner—flood-coated through a 360° coating shoe. The ingenious coating machine is likewise self-propelled, and the twin rollers, revolving behind, spiraling twin bands of asbestos felt around the pipe is one of the most colorful pieces of equipment on any pipe-line spread.

Customary practice has been to lower

the coated and wrapped pipe back on to skids above the ditch rather than to lower-in directly after the coating operation. This permits time and opportunity for careful inspection of the coat.

During construction of the Longview-Norris City leg of the line, it was found that the high quality of the coating made the expenditure of time and money for this purpose no longer advisable. The "jeep" or "holiday detector," which circles the pipe with an electric current and detects breaks or flaws in the coating, was largely furloughed. Infrequent imperfections are hand-doped and cigarette-wrapped with an additional layer of asbestos felt.

Lowering-in was done in the usual manner, although as a matter of construction interest it can be noted that heavy D-8 "cats" and the most skillful operators were generally required to lower the long sections properly without damage to the pipe coating.

Double protection for the coating was provided along many miles of the ditch by ditch padding with soft backfill earth or sand, and special care was taken in the backfilling operation to insure that heavy clods and rocks did not fall sharply against the coated pipe.

It is the general, if not the universal, conviction of both "Big Inch" engineers and construction men that the

Even with counterweights the heavy pipe sometimes made it difficult for the "cats" to keep their balance

C. HOBSON
DUNN

Pipe Line Stringing
"Common Carrier"

MAGNOLIA BUILDING
DALLAS, TEXAS

J. C. TRUMAN
CONSTRUCTION CO.
Pipe Line Contractor

Identified with pipe line industry
for over 25 years

GENERAL OFFICE
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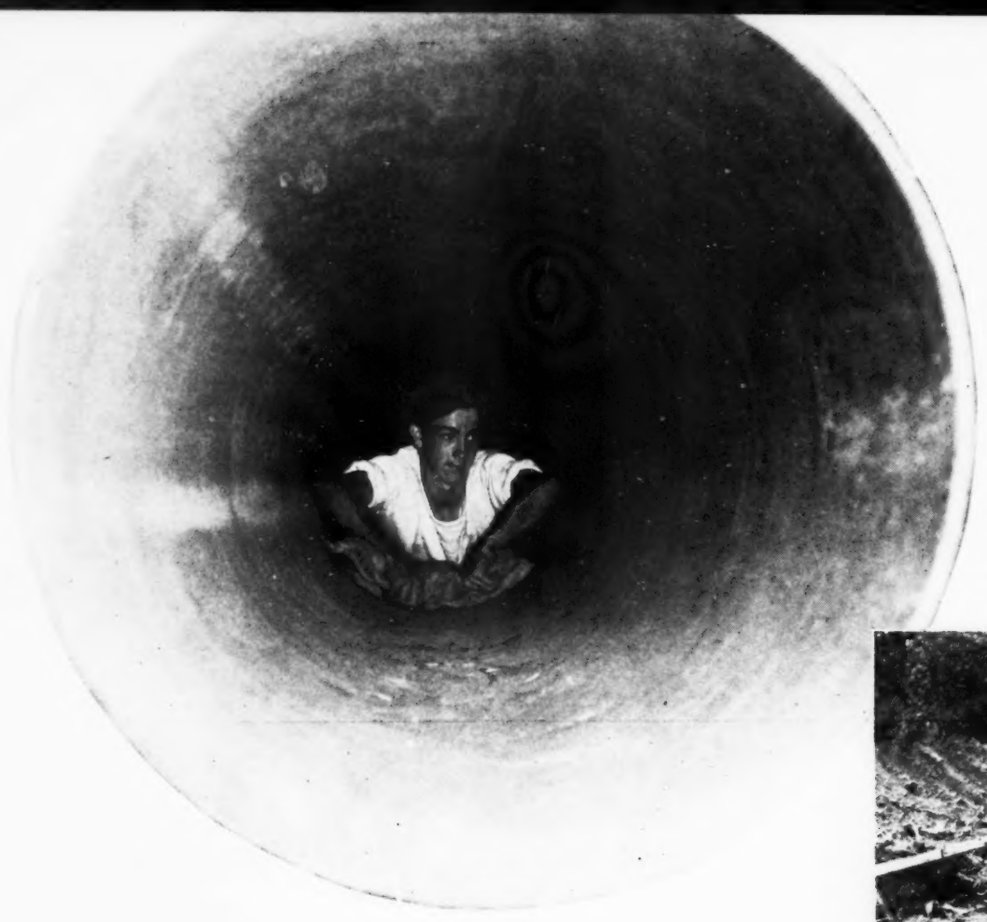


ABOVE—the human "pipe sweep" emerges from a sec tion of pipe on the "Big-Inch" line. The pipe now is clear ready to be welded on awaiting sections.

HUMAN "PIPESWEEP"

. . . HAS UNIQUE JOB ON WORLD'S BIGGEST PIPE LINE

Another Service Introduced by Oklahoma Contracting Company

This fellow has the most unique job in the pipe line construction business. We call him the human swab, or the pipe sweep.

His job is to roll through sections of the "Big-Inch" pipe line on a specially constructed scooter, pushing before him all dirt and debris accumulated in the pipe.

While his is not the most interesting or important job on the line, he does it carefully, thoroughly and conscientiously—typical of the manner in which this organization does ALL its work—from the time the right-of-way is cleared until the final scoop of dirt is pulled over the ditch.

And that's why you'll find Oklahoma Contracting service particularly advantageous whenever and wherever you have a pipe line construction job.

Our many years of successful performance; our complete outlay of modern equipment; our top-flight manpower; and our sincere willingness to work hard and conscientiously—all combine to provide an efficient, dependable and completely satisfactory pipe line service.

BELOW—pipe being lowered in the ditch of "Big-Inch" line. Oklahoma Contracting Company has completed several sections on the first lap and is now working on sections of the second lap.

Now Working On Second Lap of "Big-Inch" Pipe Line

OKLAHOMA CONTRACTING COMPANY

DALLAS, TEXAS

coating and subsequent care in lowering-in operations will pay out in terms of lower maintenance costs and overall pipe-line permanence.

River Crossings

Pipe was bent as required by the roll or curve of the ditch in either of two

Slats were wired to the pipe to protect coating and wrapper on river crossings

ways. Hot bending was undertaken when the line progressed by stove-pipe welding. Cold bending was the customary procedure when roll-welding operations formed a long section that could be suitably curved without serious danger of buckling.

Special river crossing construction was required at 5 major rivers and across several minor streams.

On these construction jobs, hand as well as machine, operations were combined to provide the "Big Inch" with maximum service security. River crossing sections were cleaned, welded, and coated by rolling on motor-driven dollies. Each section received a five-layer protective coating consisting of three

Stringing pipe along the right-of-way

regular thicknesses of coal tar enamel and two applications of asbestos felt. All sections were white-washed to permit easier and continuous inspection of the coating during the process of tying-in to the line and subsequent pulling-in to the river bed. Protection during the actual "push-pull" process was provided by binding longitudinal wooden slats around the pipe and the actual pulling of the crossings, always in an upstream arc, was accomplished in the usual manner with tractor power and cables pulling the head end and applying a multiple-cabled push on the shore end of the pipe.

Readers will recall that despite the best of river crossing equipment and

Construction by the stove-pipe method

techniques some sections of both the Arkansas and the Mississippi "Big Inch" crossings were lost during flash floods. It is a source of gratification to both PAW and War Emergency Pipelines, Inc., officials, that neither of these catastrophes materially delayed the scheduled completion of the Texas-Illinois segment of the pipe line.

☆ ☆ ☆

The cover photograph for the Pipe Line Section (page 101) is by courtesy of The Barrett Division, Allied Chemical and Dye Corporation.

FREEDOM COMES FIRST

The transportation of vital oil supplies is necessary to Victory. The O. E. Dempsey Construction Company takes patriotic pride in helping in the construction of the big 24-inch War Emergency Pipe Line, largest oil pipe line in the world.

O. E. DEMPSEY CONSTRUCTION CO.

Oil and Gas Pipe Lines

309 KENNEDY BLDG. TULSA, OKLAHOMA

Electrical Problems in Constructing War Emergency Pipeline Stations

PETROLEUM ENGINEER Exclusive Feature

☆ High mechanical efficiency and minimum operating costs expected from type of pumping equipment installed

by W. H. Stueve
Electric Power Consultant,
War Emergency Pipelines, Inc.

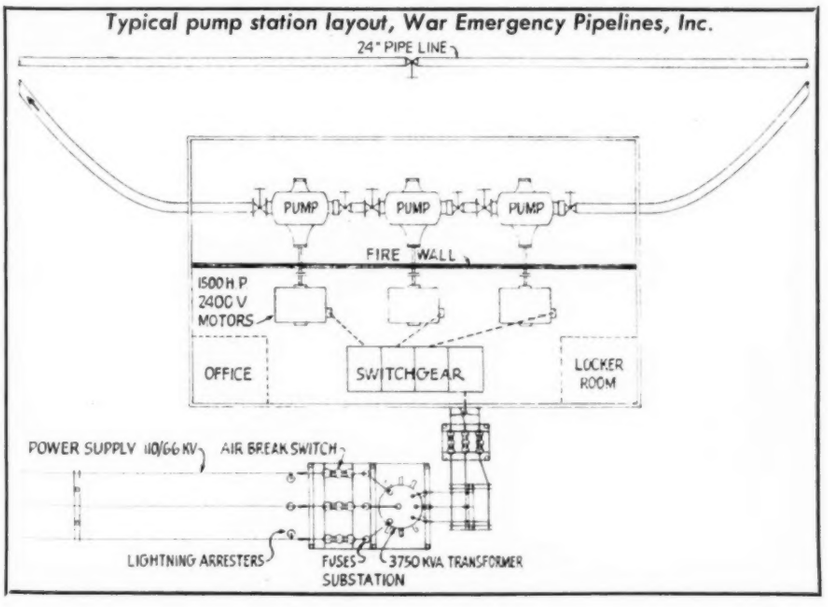
WHEN the War Emergency Pipeline project first received consideration more than 18 months ago, it was realized that large volumes of oil and/or oil products must be pumped in order to make deliveries as economically as possible to compete with ocean-going tankers and smaller diameter pipe lines being projected to Eastern States. Experience gained by the oil transportation industry through many years of operation, indicated that the limited capacities of lines of small diameter, such as 10- and 12-in., would make their use impracticable, when consideration was given to the maximum volumes of 35,000 to 60,000 bbl. per day, respectively, that pipe lines of the above diameters (the largest in use at that time) could deliver.

This study revealed that operating costs, in terms of cents per barrel per hundred miles, could be reduced to about one-third of the costs ordinarily achieved with conventional 10- and 12-in. diameter lines, provided a pipe diameter was selected to deliver five to six times the conventional volume pumped. Therefore, 24-in. diameter pipe was selected to deliver 300,000 bbl. per day with initial working pressures of the order of 700 to 750 lb. per sq. in., the same pressure as that used with the smaller lines. These lower unit operating costs expected to be achieved by the "Big Inch" pipe line are also predicated on unit operating labor savings, lower unit electric power costs, lower unit fixed charges and maintenance, and finally, better mechanical and electrical efficiencies obtainable for the pumps and motors respectively.

W. H. STUEVE

until he was "borrowed" last Summer by War Emergency Pipelines, Inc., to act as electric power consultant, was with Oklahoma Gas and Electric Company at Oklahoma City, being in charge of oil-field, pipe-line, and refinery electrification, as well as manager of the Department of Industrial Development—Is a member of the Oklahoma State Board of Registration for Professional Engineers, a member of the American Society of Mechanical Engineers and the American Petroleum Institute—Holds mechanical and electrical engineering degrees from Ohio State University.

Typical pump station layout, War Emergency Pipelines, Inc.



Fixed Charges

Table 1 illustrates the change in the items of principal operating costs, in passing from small-diameter pipes to large-diameter pipes, based on conventional practices and earlier equipment used.

Thus, by referring to Table 1, it can be noted how the unit fixed charges are greatly lowered with respect to both the actual line investment and also pump station investment. Note also that the same operating labor can operate a 300,000 bbl. per day station as is required in a pump station 1/5 to 1/10 that capacity. Note the improvement in efficiencies of the equipment as the size is increased from 700 hp. for the 10-in. pipe-line station to 4500 hp. in the 24-in. pipe-line station. Again, electric power rates generally are somewhat lower for capacities of 4500 hp. than rates for 700 hp. under similar conditions of load factors.

Other forms of pumping power also were given consideration, as were other types of pumps. Steam-turbine-driven centrifugal pumps were eliminated due to shortage of critical materials for the boilers and lack of condensing and make-up water at the remote locations of the pumping plants. Internal-combustion engines also required larger amounts of critical materials, and the engine builders were busy with marine contracts, which was also true with the speed-increasing gears required for the 1800-r.p.m. pumps. The investment required for a steam or internal-combustion engine station would be three or

(Continued on Page 136)

"BIG INCH"

Shown here are camera scenes of installation of the first of the War Emergency Pipeline pump stations, and the erection of poles for transformers. Transformers can be seen crated in one of the pictures. The 531-mile stretch of the "Big Inch" reaching from Longview, Texas to Norris City, Illinois will have 12 pump stations, all operated by Utility Electric Power. Nine of these stations are each equipped with three single-stage centrifugal pumps, each pump driven by a 1500 h.p., 1800-r.p.m., 2300-volt, constant-speed, squirrel-cage induction motor.

Electrified!

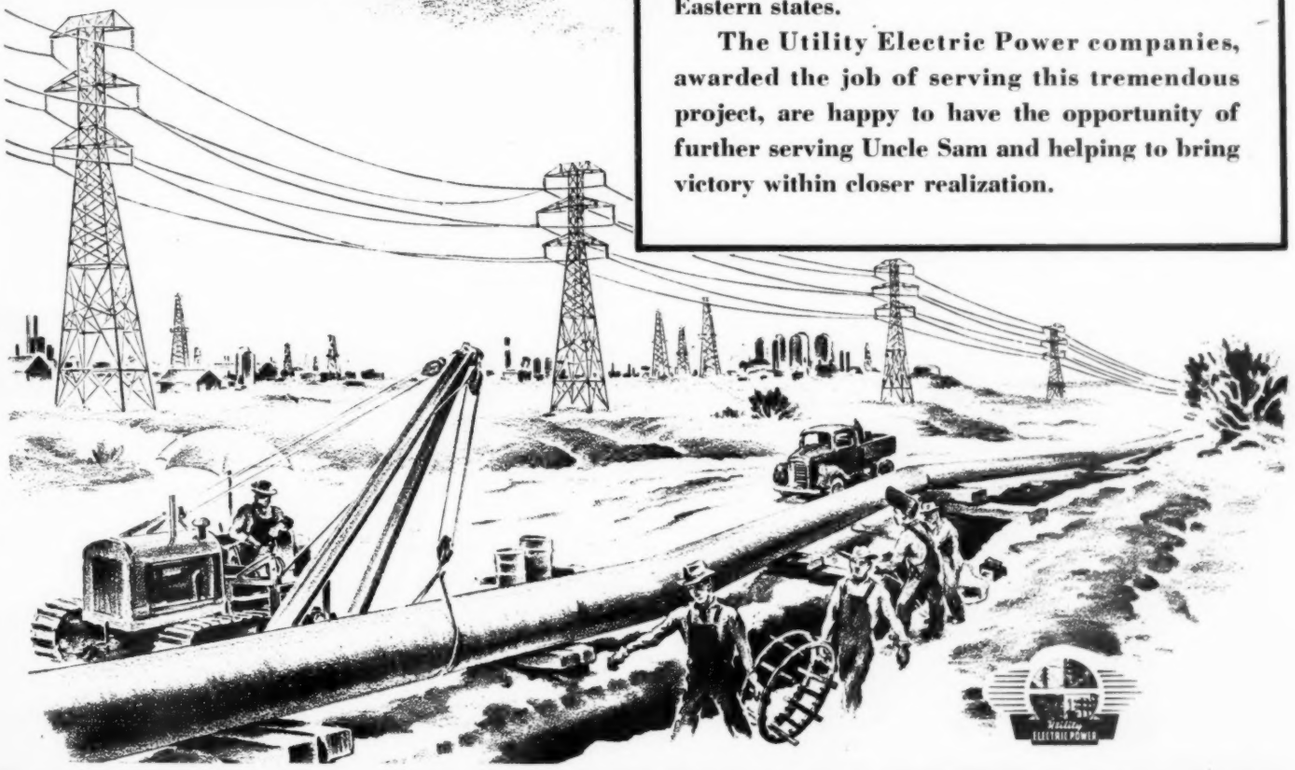
Biggest Pipe Line ever laid to be operated by *Utility Electric Power* . . . another job we're proud to do for Uncle Sam!

WITH Utility Electric Power playing such an important role already in the United Nation's march to victory, it isn't surprising that it should be selected for operating the War Emergency Pipeline—the world's largest!

Among the advantages afforded by Utility Electric Power in the operation of the Big Inch pipe line are:

Electric drive involves the least quantity of scarce materials, particularly steel; lowers the cost of installed equipment, and permits direct connection of efficient high speed motors and pumps. Furthermore, it also permits the use of smaller station buildings, simplifies operation routine, and assures low maintenance costs, since instruments accurately record electric station operations. Most important of all for the early completion of the pipe line, is the fact that only electric motor drive could be produced under war conditions in the time required to enable the pipe line to be of real benefit in alleviating the oil and gasoline shortage in the Eastern states.

The Utility Electric Power companies, awarded the job of serving this tremendous project, are happy to have the opportunity of further serving Uncle Sam and helping to bring victory within closer realization.



Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

Box 1498, Oklahoma City, Oklahoma

(Continued from Page 133)

four times greater than the electric-centrifugal station, and when consideration is given to the coöperation received from the electric power suppliers for the 26 pump stations involved, the overall pumping charges would have been a stand-off for the three conventional methods generally used and mentioned above.

TABLE I

	10-in. pipe 35,000 bbl. per day	12-in. pipe 60,000 bbl. per day	24-in. pipe 300,000 bbl. per day
First cost of pipe per mile (dollars)	11,000	13,000	55,000
Pump station costs (50 mile intervals) (dollars)	50,000	70,000	175,000
Operating labor, men per station	4.5	4.5	4.5
Kw-hr. per bbl. per 50 miles	0.33	0.3	0.25
Pump efficiencies, percent	72	75	86
Motor efficiencies, percent	92	92	95

Single-Stage Pumping Units

The high mechanical efficiency of the pumps was obtained by using single-stage units, each pump equipped with a double suction impeller and installed in a direct line, the discharge being directed into the suction of the next pump. Each pump unit will deliver full capacity but build up only about 240 lb. per sq. in., so that the three units will exert approximately 720 lb. per sq. in. for final discharge into the line. Each pump unit is driven by a 1500-hp., 2300-volt, 1785-r.p.m. induction motor.

A certain degree of flexibility in operation can be taken advantage of in these pump stations, having three pump units installed, as two units in each station can deliver about 83 percent of the maximum capacity, and one unit in each station can deliver about 55 percent of the maximum capacity. Intermediate values of capacity can be obtained by using three pumps in one station and two in the next station and by various other combinations.

The schematic diagram is shown to indicate the relative position of the pumps, motors, motor-starting equipment, and the step-down substation. Electric power is taken from existing utility lines at the voltage of such transmission lines and transformed through a three-phase, 3750-kva. transformer to usable station motor voltage of 2300 volts. This transformer is installed about 30 ft. from the pump station building directly opposite the motor-starting apparatus in the motor room of the station house.

The three-phase transformer is protected with primary fuses and also standard lightning arresters, and is equipped with four 2½ percent voltage taps in order to permit maintaining the secondary voltage of the motor supply at a constant value in case the primary line voltage of the power supply is reduced slightly under full load.

The motor-starting apparatus is either of "full voltage" or "reduced voltage" type, whichever was recommended by the power supplier as fitting their supply capacity to best advantage. When the "full voltage" starting is used the current inrush for a second or so is approximately 500 percent of the normal running current, whereas when the "reduced voltage" starting equipment is employed, the current inrush is only 210 percent of the normal running current with 65 percent of full voltage.

The losses in the 3750-kva., three-phase transformer will approximate 1.1 percent when under full load; or expressed in another manner, the no-load or iron losses are 14.1 kw., and the copper losses, under full load of 3600 kw., will be 26.0 kw.

I.C. LITTLE

PIPE LINE CONTRACTOR

TWENTY-THREE YEARS EXPERIENCE

MAIN OFFICES: 1102 GULF STATES BLDG.

DALLAS, TEXAS

Central Warehouse, Valley Park, Missouri

TABLE 2

Pump station	Location	Power utility	Miles of power lines	Supply kv.
A	Baytown	Houston Lighting & Power Co.	2	33
B	Beaumont	Gulf States Utilities Co.	5	33
C	Singer	Gulf States Utilities Co.	18	33
D	Lotus	Louisiana Power & Light Co.	56	110
E	Bienville	Louisiana Power & Light Co.	17	110
F	El Dorado	Arkansas Power & Light Co.	7	110
G	Fordyce	Arkansas Power & Light Co.	3	110

Power Line Construction

In procuring sufficient power for the first pump stations from Longview, Texas, to Norris City, Illinois, or No. 1 to No. 11, it became necessary to construct 0.1 mile of 33-kv., 30 miles of 66-kv., and 82 miles of 110-kv. power lines, from existing power lines to the pump station substations.

Due to the critical shortage of copper, the War Production Board ordered the use of steel conductor on the 112 miles of station feeder power lines. After considerable difficulty in obtaining the electrical characteristics of the proper economic steel conductor, a 7-strand high-strength, ½-in., extra galvanized wire was selected, having the following characteristics: When carrying 30-amp. 60-cycle electric power at 30°C. its resistance will be 2.6 ohms per mile, and with 18 ft. equivalent spacing of conductors its reactance will be 1.25 ohms per three-phase mile.

When this conductor carries 50 amp. the above values are increased about 5 percent. When the equivalent spacing is reduced to 9 ft. for the 66-kv. lines, the reactance becomes 1.09 ohms per three-phase mile when carrying 30 amp.

The use of the steel conductor on the power line installed from existing supply lines to the respective pump station substations will cause losses at full load in such 112 miles of feeder lines of approximately 600 kw.; whereas, if aluminum cables-steel reinforced could have been procured, these feeder line losses could have been reduced to about 150 kw., representing a saving in power of perhaps $30,000 per year. If hard-drawn copper could have been procured for use as conductors, the power losses in the 112 miles of feeder lines could have been further reduced to about 75 kw.

Although the power factor of the motors at full load is expected to approach 92 percent in the pump stations, the capacity effect of the feeder power lines will tend to improve the power factor in these supply lines to such an extent as will make the current flowing in such lines, about 5 percent lower and, therefore, reduce the power losses about 10 percent. This situation, however, was taken into account in the above 600-kw. estimate of losses.

Eastern Extension

On the 857-mile extension of the pipe line from Norris City, Illinois, to Bayonne, New Jersey, and Chester, Pennsylvania, or from Pump Stations No. 12 to No. 26, the power supply has been arranged for through power utilities serving that area.

In practically all cases, the feeder power lines will be constructed at no cost to the pipe line, and the 3750-kva., three-phase step-down transformer will be installed by the pipe line.

The total power required for the operation of the 26 pump stations amounts to 95,000 kw., representing a cost of procurement of this capacity to both the pipe line and the power supplier, including step-down transformers, and the power utilities' feeder line

CO-OPERATION of business managed electric companies, including Southwestern Gas and Electric Company, with the oil industry and with the government was necessary to boost fuel oil "along the line" to vital war industries and ports in the East. Thus, we at Southwestern were able and honored to help still further in America's war effort. Furnishing cheap electric power to oil fields, factories and homes is routine with us. And yet we still have ample reserve to take care of any new emergency call that may be placed on us. No job is too small or too large and we're always ready. Complete information may be obtained through our oil field offices in Gladewater, Henderson, Kilgore or our home office in Shreveport.

SOUTHWESTERN
GAS & ELECTRIC COMPANY

Ready to lay the "Big-Inch" through some rough country on Section Seven of the War Emergency Pipe Line.

•

WE HAVE RECEIVED THE CONTRACT FOR SECTION TEN OF THE WAR EMERGENCY PIPE LINE EXTENSION TO THE ATLANTIC COAST.

MODERN EQUIPMENT AND EXPERIENCED PIPELINERS WILL GET THE JOB DONE.

•

RAY L. SMITH CONSTRUCTION CO.

Pipe Line Contractors

Hazlett Building El Dorado, Kansas

extensions, including all reinforcement of power systems, of $21.50 per kw.

It is estimated that the power required will be 7 kw-hr. per bbl. pumped and the annual power bill will closely approximate $6,000,000. With reasonable fixed charges, including overhead, maintenance, operating labor, another $8,000,000 would be added to the power bill, making the total annual operating cost about $14,000,000 to pump 100,000,000 bbl. of oil and/or oil products through 1400 miles of line. This resolves the economy of the line into a pumping cost of about 1 cent per bbl. per hundred miles, or 14 cents per bbl. for delivery from Texas to New Jersey tidewater.

The long-life operation of the line should, therefore, be assured when considering the oil tanker costs of 15 to 20 cents per bbl. delivery from Gulf ports to Eastern tidewater.

Proposed Products Line

As it is now assumed that the 20-in. oil products line will be constructed from Beaumont and Houston, Texas, to the East Coast, it is proposed that it will meet the present 24-in. War Emergency Pipeline at No. 5 Station at Little Rock, Arkansas, and thence parallel the 24-in. line. Each station would be equipped with three 1250-hp. motors operating single-stage pumps operating at the same working pressures as the 24-in. line, of perhaps 700 lb. per sq. in. in order to deliver about 235,000 bbl. per day, with pump stations about 53 miles apart on the same property as the 24-in. pump stations.

Power procurement on an alternate route for this 20-in. products line, passing through Louisiana, Northwest Mississippi, Tennessee, West Virginia, and Pennsylvania, was quite involved and required an investment of about $45 per kw. of capacity, or more than twice that of the selected parallel route. Other operating economies, such as reduced right-of-way costs, lower station labor, lower electric power costs, and lower operating maintenance, will be achieved by the parallel route.

The distance from Beaumont (Spindletop Tank Farm) to the 24-in. crude line station No. 5 at Little Rock, Arkansas, is about 350 miles. Thus, the 20-in. products line will be only about 150 miles longer than the crude oil line.

The motors selected, of the 1250-hp. class, will be 3570 r.p.m. or two-pole, to operate the single-stage centrifugal pumps at the same speed. This conclusion was reached in the interests of saving critical materials in both the pump and motor; also, some few points better efficiency can be obtained.

The power utilities, already arranging to supply capacity of 4500 hp. at each station from Little Rock to the East, have indicated their ability to have capacity also to supply 3750 hp. at the various pump stations.

On the parallel portion of the line; namely, from the 24-in. station No. 5 to its present terminus at Seymour, Indiana, or station No. 14, the pump houses will be separated only slightly, perhaps 100 ft., and it is proposed to install an additional 3750 kva., three-phase transformer, having a common primary bus, but the secondary (2400 volts) will pass to its respective pump house.

It is proposed to arrange a bus-tie arrangement with proper switches installed, so that in the event of failure of one 3750-kva. transformer, the other can with the aid of air blast blowers be connected to permit capacities of 5000 kva. to be available for both the 24-in. line's pumps and 20-in. line's pumps. The selection of the number of these respective pumps would depend on the urgency demand of the respective fluids to be pumped. For short durations of time, two pumps in each pump house could thus be operated, requiring about 4500 kw. or 5000 kva., and yet continue to deliver 83 to 85 percent of the maximum capacity of both pipe lines.

A cursory survey of the country between Little Rock and Beaumont indicates the procurement of power for seven pump stations will require additional power lines to be constructed as shown in Table 2.

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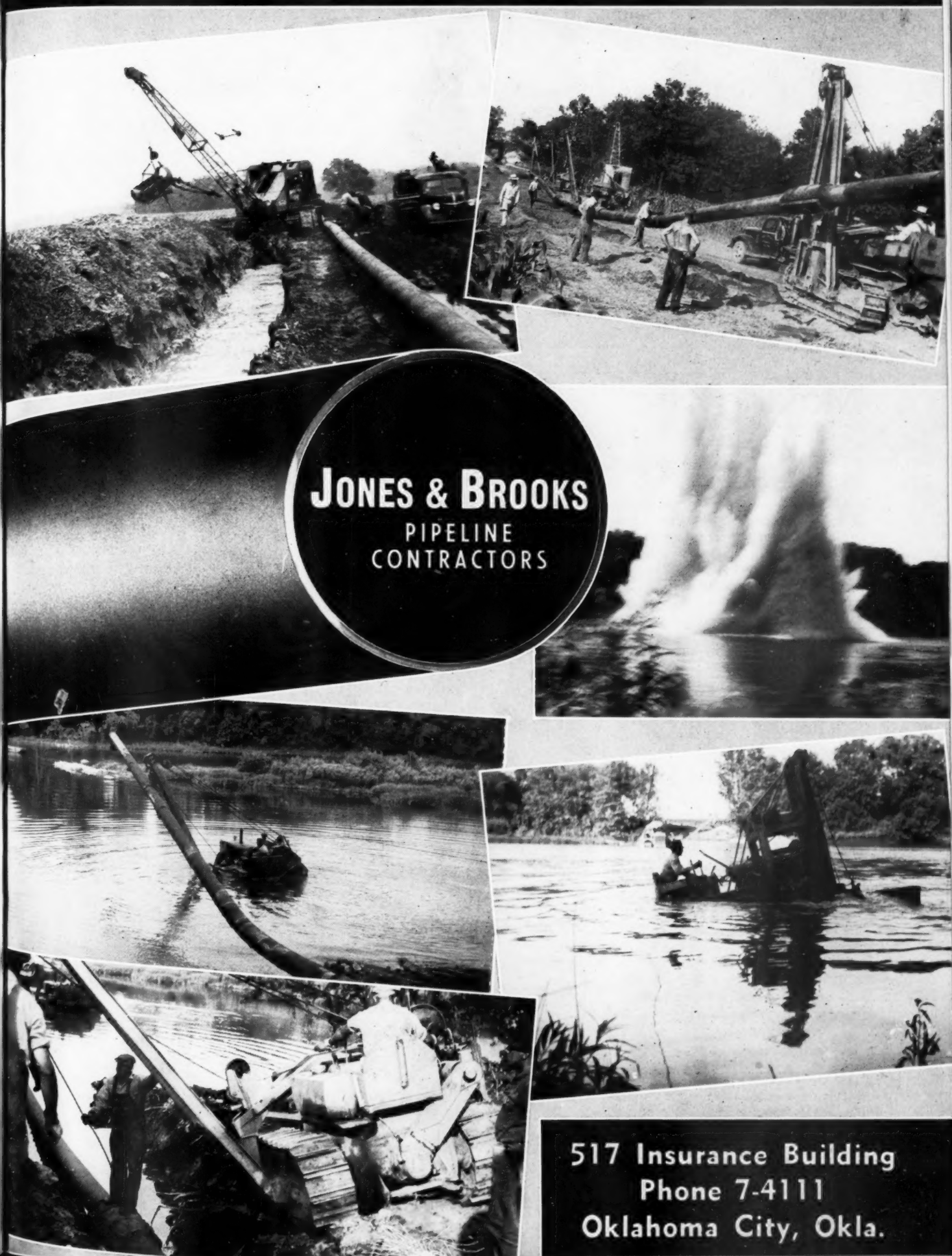
Scenes of Various Construction Projects Recently Completed by Jones & Brooks



JONES & BROOKS

PIPELINE CONTRACTORS

517 Insurance Building
Phone 7-4111
Oklahoma City, Okla.

P 615.2
P 094.11

By the trainload "Big Inch" pipe leaves the mill daily on its journey to unloading stations along the right-of-way

PETROLEUM ENGINEER EXCLUSIVE Feature

by

Frank H. Love

Managing Editor

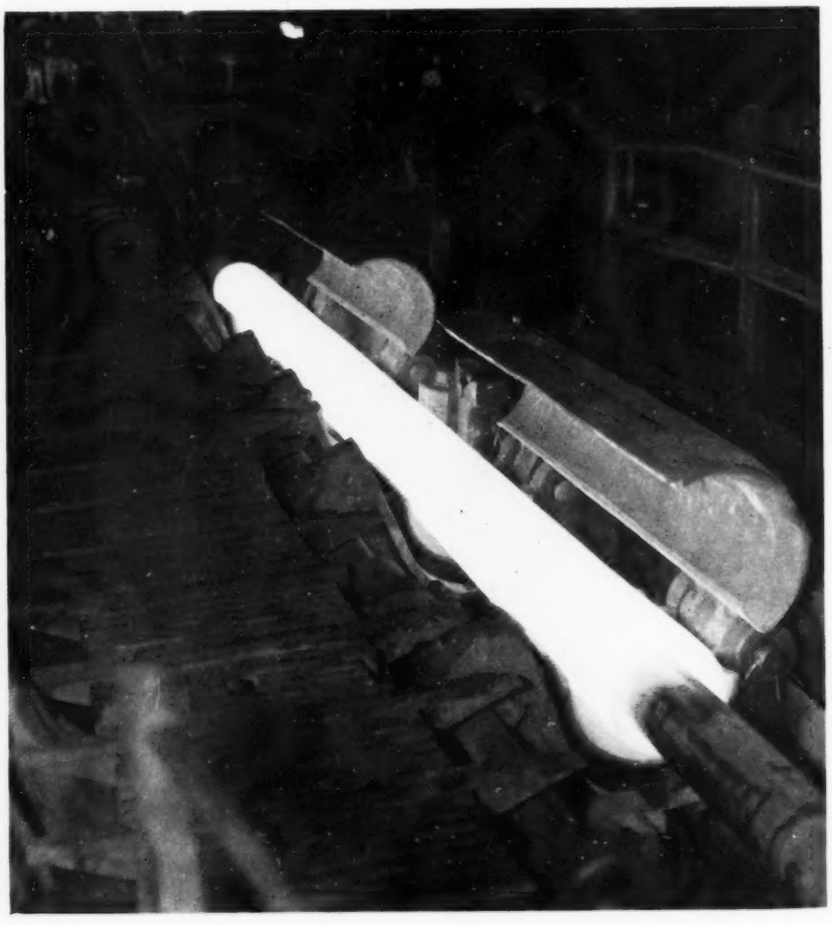
Making The "Big Inch" Pipe

☆ An account of the procedure involved in the manufacture of the large-diameter pipe in record-breaking time

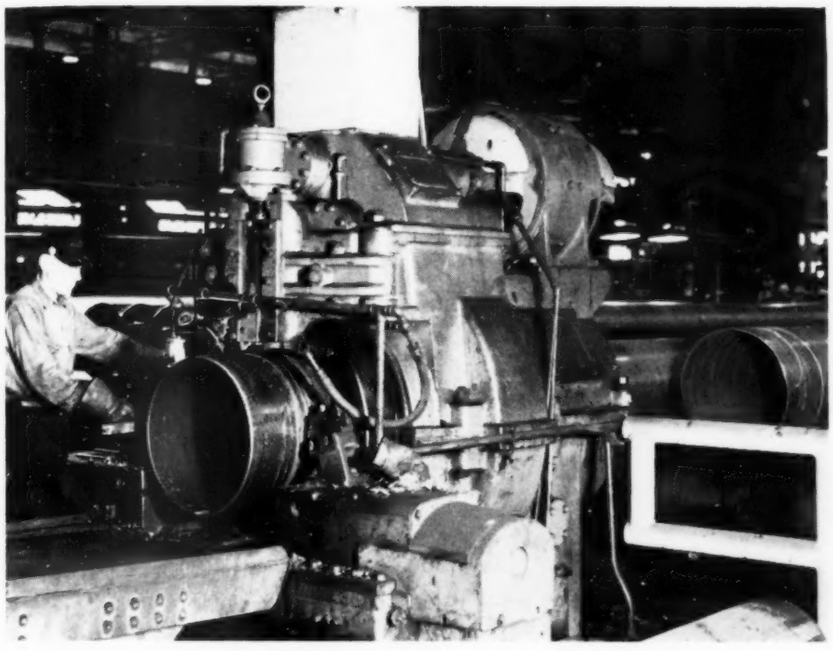
ANY comprehensive account of the War Emergency Pipelines' "Big-Inch" line from Texas to the East patently would be incomplete without the story of how the 24-in. seamless line pipe was manufactured.[1] Without detracting from the outstanding manner in which the construction personnel accomplished the laying of the first unit of the line, continuing their record-breaking speed on the second "leg" of the project, it can justifiably be said that the making of this large-diameter pipe on a schedule requiring a total of 70,000 separate 41-ft. lengths in a period of 124 days was also an almost incredible accomplishment. To attain and maintain this schedule, which, in more understandable terms, represented a production of 45 carloads of pipe a day, a carefully planned procedure involving men, materials, and machines was essential. That this planning was sound is attested to by the fact that the originally designated production schedule was adhered to so completely that the final length of pipe was finished within the hour originally set for the fulfillment of this enormous undertaking.

Although primarily this is a description of the procedure for making the pipe, properly to understand the size and proportion of the achievement it is not amiss to discuss briefly the requirements for maintaining an unbroken supply of solid rounds of steel at the initial heating furnaces ready for piercing. Production of a single length of pipe 24 in. in diameter, averaging

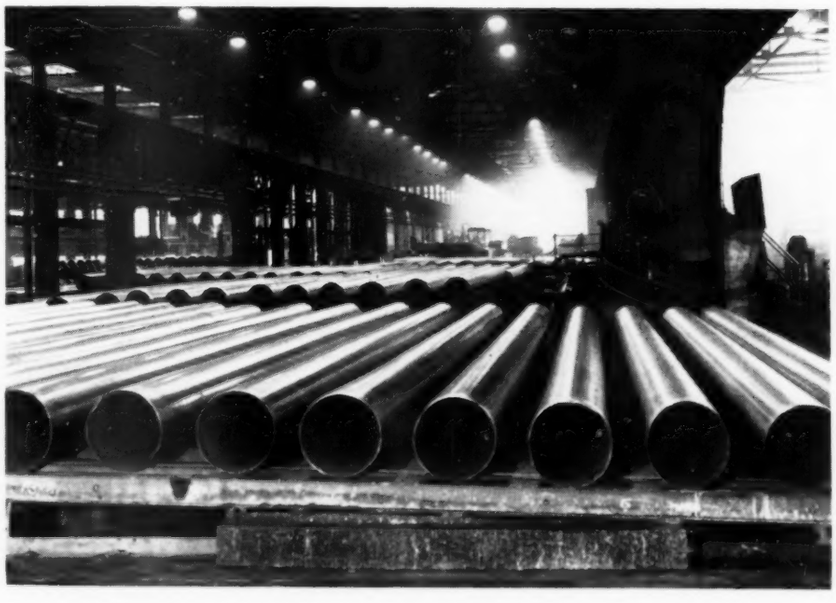
[1]By National Tube Company at the Lorain, Ohio, mill.



Piercing the solid billet of steel—the heart of the seamless process. It is here that life begins for the "Big Inch"



Cutting-off and end beveling—one of several finishing operations prior to final test and inspection



On the cooling table. "Big Inch" in a constant stream day and night rolls on to finishing department

41 ft. in length, and weighing approximately two tons requires ton upon ton of iron ore, limestone, and coke to produce the necessary quantity of steel. This steel is produced by the open hearth process in large unit quantities and is tapped into ladles that convey the hot metal to the pouring platform where it is teemed into molds to form ingots, each of which weighs approximately 11 tons. After the molds are stripped from the ingots the latter are placed in soaking pits and brought to the proper temperature for rolling. They are then rolled into rectangular blooms and, without reheating, are converted into round billets. This operation takes place in the bar mill. Before delivery to the pipe mill the billets or "rounds," which are 1 ft. in diameter, are sawed into 12-ft. lengths and are passed through a peeling machine that "skins" the surface to a depth of 1/16 in. Any remaining surface defects are removed by chipping. The billet is now ready for the pipe-making process, each 12-ft. length containing enough metal to make one 41-ft. joint of pipe.

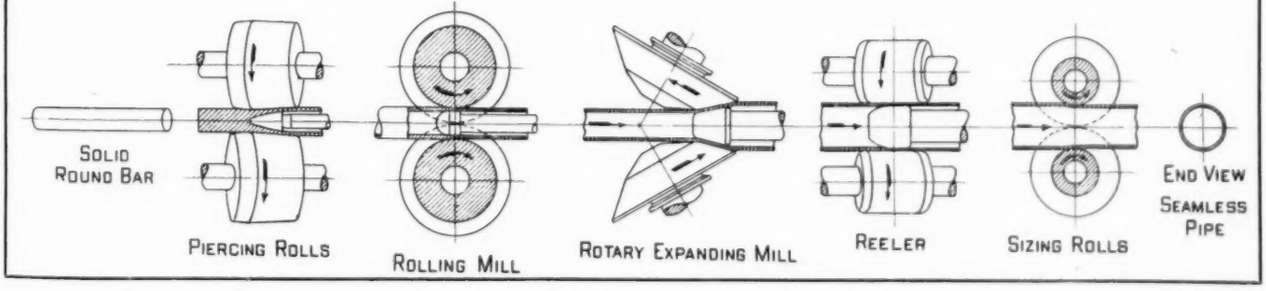
Pipe-Making Process

In the pipe mill the billets or rounds are charged to heating furnaces as the initial step for their journey through the seamless mills. Heating of the steel is a critical stage of tube making and only skilled workmen specially trained in the art are permitted to perform this function. When at the proper forging heat (approximately 2250°F.) the billet is pushed into the rear of the piercing mill where it is gripped between powerfully driven rolls and forced over a mandrel held between the rolls. Now begins the transformation of a solid steel billet into a hollow forging. Emerging from the piercing mill, the hollow billet is a relatively thick-walled tube, fairly uniform in wall thickness, and somewhat rough on its surface.

The first piercing operation is followed by a second similar one, wherein the wall thickness is reduced and the diameter and length increased.

The piercing operation is one of the most severe tests that any steel is re-

The seamless process of making pipe in diagram. For brevity certain operations are not illustrated, including a second operation similar to piercing rolls shown



National Tube Company executives who negotiated the order for the "Big Inch" line and accepted the responsibility for delivery of the pipe in record time. Reading left to right: John E. Goble, vice-president in charge of sales; W. F. McConnor, general manager of sales, and C. R. Cox, executive vice-president

quired to withstand in the process of initial fabrication. The tremendous power driving the rolls that force the billet over and around the mandrel is extreme treatment and only fine-grained homogeneous steel can pass this test.

The tube as it comes from the second piercing operation is rather short and its walls are thick. The next requirement is to increase the length by reducing the wall thickness. This is accomplished by reheating the tube and rolling it in two passes through grooved rolls over a plug held in the roll groove on a bar. To increase the diameter, the tube is immediately reheated and transferred to the rotary expanding mill. Here it is gripped by a set of conical disk rolls, rotated rapidly, and rolled over a tapered mandrel situated between the revolving disks. This increases the diameter without greatly increasing the length of the tube.

The pipe is now assuming shape. Insofar as length, diameter, and approximate wall thickness are concerned, the pipe is almost made. Other important operations are to follow, however, before the pipe is completed.

From the rotary expanding mill the pipe is conveyed through the breakdown sizing machine to the reelers, where it is reeled between cylindrical rolls and over a plug to remove surface irregularities. Emerging from this process the pipe is smooth inside and outside, and has an exterior burnished finish. After being reeled the pipe is passed through a reheating furnace, then to the sizing machine where uniformity of size, or circularity, is produced. The importance of this characteristic to later lining-up for welding in the field is obvious. To remove any margin for error in the matter of sizing, the pipe is passed through a second sizing machine.

The final basic operation is straightening. A specially designed rotary straightener gives the pipe uniform straightness from end to end. When the pipe reaches the finishing department it is given a preliminary inspection after which each end is cut off, leaving a smooth machine-finished edge, which is beveled to 30-deg. to facilitate welding in the field.

Before the final rigid inspection is made, the individual joints of pipe are given a hydrostatic test of approximately 875 lb. The final inspection includes gauging for proper wall thickness and roundness. Rough areas on the surface also are marked by the inspectors and these are ground smooth with emery wheels to remove the possibility of their damaging coating or wrapper when laid.

After the name of the manufacturer, length, weight, and test pressure have been stenciled inside each joint, the pipe is loaded into cars, which in turn are assembled into trainloads ready for the journey to designated places along the line. An idea of the loading and car-handling problems involved can be gained from the fact that pipe for the first unit of the line was manufactured at the rate of 5½ miles a day—1375 tons, making a trainload of 45 cars.

This, then, is the manner in which the "Big Inch" pipe was made, from iron ore to finished product in a cycle of operations requiring approximately 72 hours, accomplished by the coördinated effort of workmen and supervising staffs keyed to their task by the knowledge that theirs was a work vitally essential to the war effort—that of moving crude oil to the Eastern area primarily for refueling warships and for shipment to mechanized armies on the European battle fronts.

☆ ☆ ☆

In the mill. Some of the workmen who man the principal operations in making the "Big Inch" pipe. Left to right: John Ivancic, heater; John Stuowski, piercer plugger; Irving Higgins, hi-mill roller; Steve Pastor, rotary roller; Anthony Aleskin, reelerman, and Matt Pozega, straightener

SHEEHAN

Sheehan Crews have made a substantial contribution to War Emergency Pipe Lines, Incorporated's epoch-making construction record.

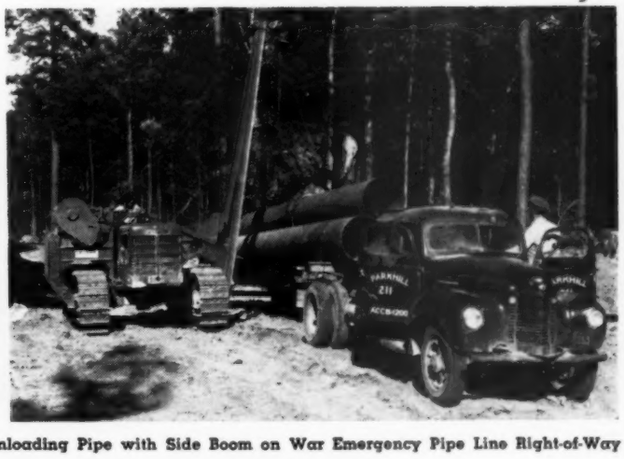
SHEEHAN PIPE LINE CONSTRUCTION COMPANY

JOHN B. SHEEHAN, *Manager*

NATIONAL BANK OF TULSA BUILDING **TULSA, OKLAHOMA**

PARKHILL TRUCKS Have Gone to WAR WORK

Hauling Contractors Heavy Equipment on Low-Boy Trailer



Unloading Pipe with Side Boom on War Emergency Pipe Line Right-of-Way

Parkhill is hauling and stringing approximately half the pipe on the North extension of the War Emergency Pipe Line.

- Pipe Line Stringing Contractor
- Common Carrier
- Pump Station Machinery Hauling
- Where Pipe Lines Are Under Construction, You Will Find Parkhill on the Job.

We operate in 31 states under ICC Permits MC-30188 and MC-30188 Sub. 3.

- MODERN EQUIPMENT AND EXPERIENCED WORKMEN
- EFFICIENT, RESPONSIBLE

Established 1920

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2000 E. Jasper General Offices: TULSA, OKLAHOMA Phone 4-6159

4 WAYS to get more service from WIRE ROPE

Yes, wire rope is tough. It can stand up to the most rigorous service—and ask for more.

But that's no reason to abuse it. With a little care, by applying a few simple rules, you can get a tremendous amount of extra service from your rope.

1 Break it in with light loads

For example, when breaking in a new rope, don't slam on full power and speed right off the bat. Begin with fairly light loads. Operate at moderate speed. Give the strands of the rope a chance to seat down snugly and uniformly upon the core, so that each strand is carrying its fair share of the load. This way, the rope will assume its proper "constructional stretch" without damage, and you'll be assured of better spooling and easier handling throughout the entire life of the rope.

2 Treat it with consideration

After the rope is broken in, you can safely use whatever speeds and loads it was designed for. But don't be unnecessarily rough, even then. A smooth, gradual application of power is just as efficient as slamming into the load with a jerk. The same is true of braking. It's the heavy jerks and surge loads that beat the guts out of a piece of rope. Nine times out of ten these can be avoided without losing time.

3 Know your rope

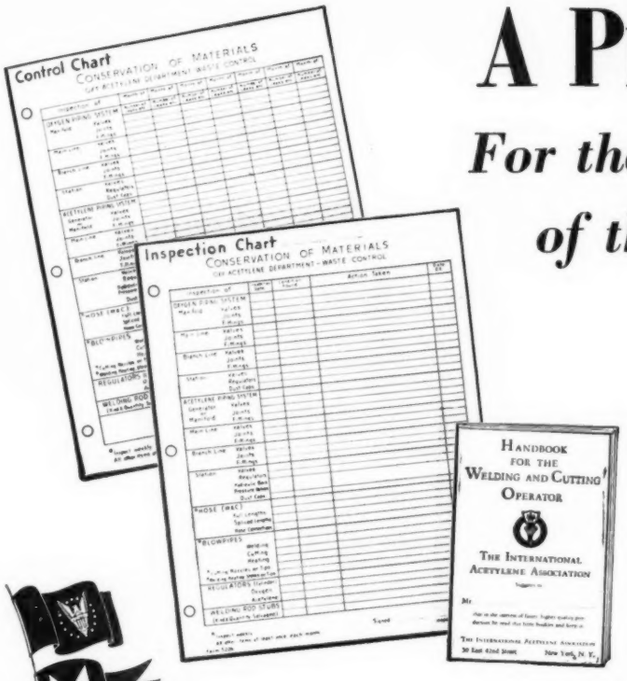
For example, if you're using a flexible 8-strand rope for high-speed work, don't overload it. This rope is built to withstand bending fatigue and fast operation—not for heavy hogging lifts. The opposite is true of heavy-duty 6-strand rope. Lift with it—but don't try to break speed records.

4 Right maintenance means plus service

Don't neglect the few simple maintenance precautions which require so little time yet return so much in extra service. Keep your rope properly lubricated. Don't operate it over sheaves that are abraded, damaged, or out of line. Fasten clips in the approved manner. Cut off a short length from the drum end of your rope from time to time so that "grief spots" are relocated over sheaves and drums.

Wire rope is now a war weapon. Its proper use is a service to your country and to yourself. If you want good, dependable rope, and friendly service, get in touch with the Bethlehem Wire Rope distributor in your territory. He's always ready and willing to serve you.

Bethlehem Manufactures Wire Rope for all Purposes



MARITIME "M" AWARD FOR OUTSTANDING PRODUCTION ACHIEVEMENT

A PLANNED PROGRAM

For the Control of Waste in use of the Oxy-Acetylene Process

The greatest over-all losses of oxygen and acetylene come from little things at many points—such as small leaks at fittings, leaky hose, and minor faults of operators, both experienced and new. An effective method for control of such waste must strike at each one of these small points.

Elimination of leaks and wasteful practices requires a planned program, the responsibility for which must be shared equally by management and operators. To help put such a program into effect, the Linde organization suggests the following plan be adopted—modified as needed to fit each shop.

1. **Appoint an inspector** to check regularly the piping system, the hose, and the apparatus while the equipment is in operation. Besides soapy water and a brush to test for leaks, wrenches, and a simple repair kit, he should have some form of INSPECTION CHART such as that shown above and a map of the oxy-acetylene system on which to record tests, repairs, and other pertinent information. *Sample copies of this chart (Form 5206), and of a map (Form 5207), will be sent by Linde without charge.*

2. **Summarize the inspection data** on a master CONTROL CHART such as that shown above. This will give plant executives an over-all picture of the waste control program. *Copies of this chart (Form 5205) are available from Linde.*

3. **Co-operation of every operator** should be solicited for the success of this waste control program. To remind operators of the many little ways in which waste can be avoided, Linde will send as many copies as you need of a vest-pocket-sized booklet, published by the International Acetylene Association, that presents the conservation story in a series of illustrated "do's" and "don't's." *Every operator should have a copy of this little handbook.*

The program outlined above will not only help to assure continued adequate supplies of oxygen and acetylene, but should also more than pay for itself in lowered costs and increased efficiency. For samples of the charts described above, and for handbooks for your operators, send the coupon, or ask any Linde office.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

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In Canada: Dominion Oxygen Company, Limited, Toronto

THE LINDE AIR PRODUCTS COMPANY
30 East 42nd St., Room 308, New York, N. Y.

Please send me, without charge, the material I have checked.

☐ Conservation of Materials—Inspection Chart—Form 5206.

☐ Specimen Inspectors' Map of Oxy-Acetylene Piping System—Form 5207.

☐ Conservation of Materials—Control Chart—Form 5205.

☐ Handbook for the Oxy-Acetylene Operator—published by the International Acetylene Association.

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LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks.

Specially designed equipment was used to coat and wrap pipe in the field

PETROLEUM ENGINEER Exclusive Feature

Difficulties in Laying Gulf Coast Line

PIPE lines through the swampy Gulf Coast area are almost without exception difficult to lay. Construction of 8- and 10-in. Port Arthur-Paradis line by The Texas Pipe Line Company proved no exception. Some idea of the difficulties encountered may be gained by considering that as many as 11 bayous and canals were crossed in a distance of one mile, some of the swamps were as wide as 20,000 ft., and, in addition, numerous rivers had to be crossed.

Conventional ditching equipment, obviously, could not be used in the marshes, and here the practice was to make the ditch with a plow pulled by marsh buggies. The joints of pipe were welded on solid terrain and the "strings" pushed into place by tractors equipped with back-end winches. In some of the more accessible swamps it was possible to build ramps from which to lay the pipe. Some of the swamps were full of cypress knees, or stumps, and these were removed by shooting or by a dragline operating from the artificial mats. Another ingenious construction method used when other methods were impossible was to string pipe by means of "mud boats" pulled by tractors. This equipment is made of steel and, as its name implies, resembles a boat.

Coating

All pipe laid through swamps, bayous, and rivers was coated in a central yard. Otherwise the coating and wrapper were applied by a traveling-type machine. For the first time a specially constructed machine was used, one designed to apply more than one coating and wrap. This machine was constructed at the instigation of A. S. Bailey, general manager of The Texas Pipe Line Company. Shown in an accompanying illustration, the machine contains two coating and wrapping heads; however, it is no longer than conventional equipment and thus can readily negotiate bends, sags, etc. Design permits the machine to make six different applications. It can apply (1) one coat and one wrap, (2) two coats and one wrap, (3) two coats and two wraps, (4) one coat and two wraps, (5) a coat and a wrap and a coat and a wrap, and (6) a coat and a wrap and a coat and two wraps. On this particular job the procedure followed in the field was to apply a coat and a wrap and a coat and a wrap. When coating and wrapping the pipe in a central yard with a stationary machine the same application was made except that a kraft paper wrapper was placed overall.

All navigable rivers were provided with dual crossings and the lines were buried beneath the river bottom. Pipe used in river and stream crossings was coated with Somastic. The widest river crossing was the Sabine, which was 2600 ft. wide. The Intercoastal Canal, 1000 ft. wide, was crossed twice; other crossings included the Calcasieu River, 1700 ft. wide; Lacassine River, 500 ft.; Lake Arthur, 1500 ft.; Vermilion River, 300 ft.; Bayou Tigre, 300 ft.; Wax Lake, 600 ft., and Atchafalaya River, 1500 ft. This last river is 80 ft. deep.

Line Pipe Reconditioned

The total length of the line is 230 miles and it was laid entirely of reconditioned pipe. The 125 miles of 10-in. pipe laid from Port Arthur to Erath, Louisiana, was taken up in West Texas between Del Rio and Lytle. This was an old screw line of 20-ft. joints. The pipe was shipped to Louisiana, the collars cut off, the pipe reconditioned and triple-jointed, or welded into joints averaging 62 ft. in length. These extra length joints were adopted as a means of speeding-up construction time.

The 8-in. pipe was taken up in East Texas and Oklahoma and, after being reconditioned, was also triple-jointed. This work was done at Orange, Texas, and the pipe was shipped by barges through the Intercoastal Canal and unloaded at designated points from which it was strung.

Most of the line was electric-welded; however, about 40 percent of the 10-in. pipe was welded by the pressure-weld method, a process described elsewhere in this issue of *The Petroleum Engineer*.

In certain areas where conventional ditching machines could be used, because of the caving nature of the soil the ditchers were provided with specially constructed slopers, which gave the ditch a sloping angle on the upper edges, preventing much of the caving.

Sharman and Allen of Houston, Texas, contracted the laying of the line.

☆ ☆ ☆

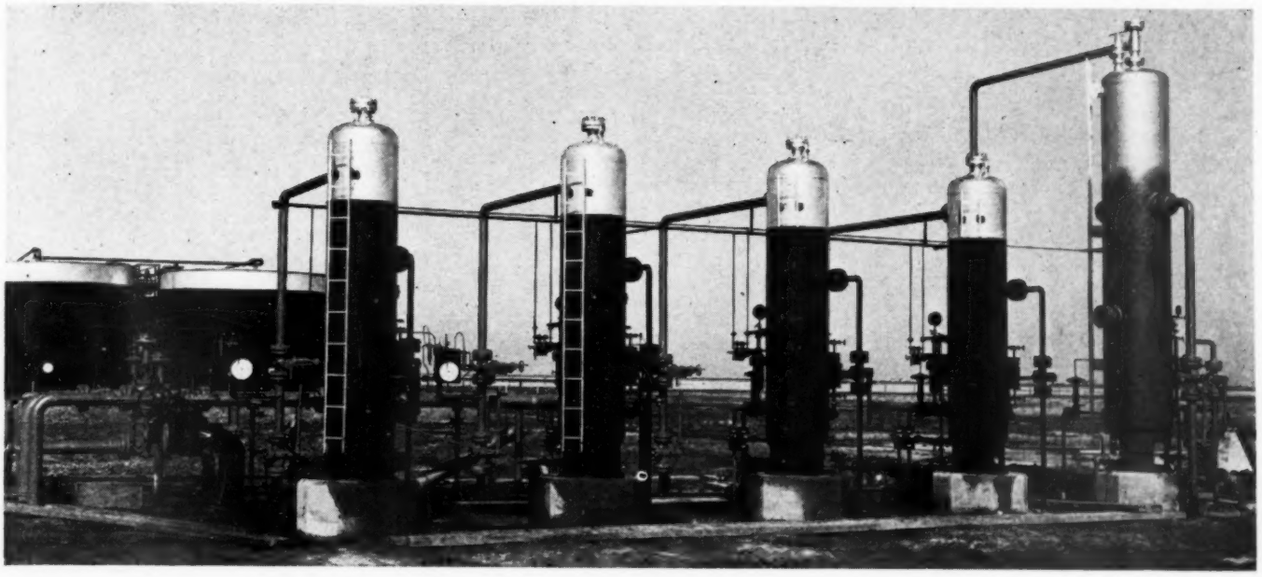


Fig. 1. General arrangement of the high-pressure separators in the field

Multiple-Fluid Pipe Line

PETROLEUM ENGINEER Exclusive Feature

☆ **Flowing oil and gas simultaneously through same line proves practicable**

by F. B. Haverfield

Assistant General Superintendent,
Natural Gasoline and Gas Division, Continental Oil Company

THE earliest record of a pipe line for transporting hydrocarbon fluids appears to be that of a wooden line laid at Fredonia, New York, in 1821. In 1825 a short line was constructed of lead pipe. Both of these lines were used for transporting natural gas.

A review of the history of oil pipe lines reveals that the first oil pipe line was suggested in November, 1860, by General S. D. Kains at Parkersburg, West Virginia. A project was developed to handle oil through a gravity system from Burning Springs to Parkersburg, but the line was never constructed. In 1862 several short oil lines were completed, and from that date, pipe lines have generally kept pace with exploration and development throughout the petroleum industry.

Accompanying the general expansion of pipe-line systems there has been rapid development in pumping equipment, and there is available at the present time suitable types of machinery for pumping both gas and oil under practically any condition desired.

It has been standard practice, for many years, to handle different grades of crude oil, or other liquid hydrocarbons, through a single line between destinations by batching. Elaborate dispatching and control systems have been perfected to the extent that the exact location of each batch in the pipe line, or quantity of liquid product being shipped, is at all times known. Automatic pipe-line transmission equipment is now in use and has greatly facilitated batch movement of products. Miscible fluids, however, have not been transported simultaneously through the same line, as there is no way to effect a simple separation at the point of discharge.

Light hydrocarbon fluids that are normally gaseous are readily separated from the heavier liquid hydrocarbons under most conditions of temperature and pressure that exist in ordinary pipe-line practice. This fact suggested the use of a single line for the simultaneous pumping or transporting of such fluids.

Continental Oil Company's Lake Arthur field near Jennings, Louisiana, produces a light oil and gas. The liquid recovery is readily obtained in field separators by reducing the flowing pressure to within retrograde condensation

F. B. HAVERFIELD

became affiliated with the petroleum industry as a pumper in the Delaware, Oklahoma, pool in 1921—In 1923 he was made chief operator of a booster station for the Henderson Gasoline Company—In 1926 he went with the Signal Oil and Gas Company, in charge of its gasoline plant in the Big Lake, Texas, field and remained there until 1936—The Big Lake field then had the world's record for deep producers—In 1936 he joined Continental Oil Company as superintendent of the Tepetate, Louisiana, Stabilization, Natural Gasoline and Pressure Maintenance Plant—He is directly responsible for many of the innovations incorporated in this plant, which has pioneered many new features of recovery control—In recognition of his work and ability, he was promoted to the position of assistant general superintendent of the Natural Gasoline and Gas Division of Continental Oil Company, which position he now holds—He is recognized as a leader in high-pressure gasoline and pressure-maintenance plant operations.

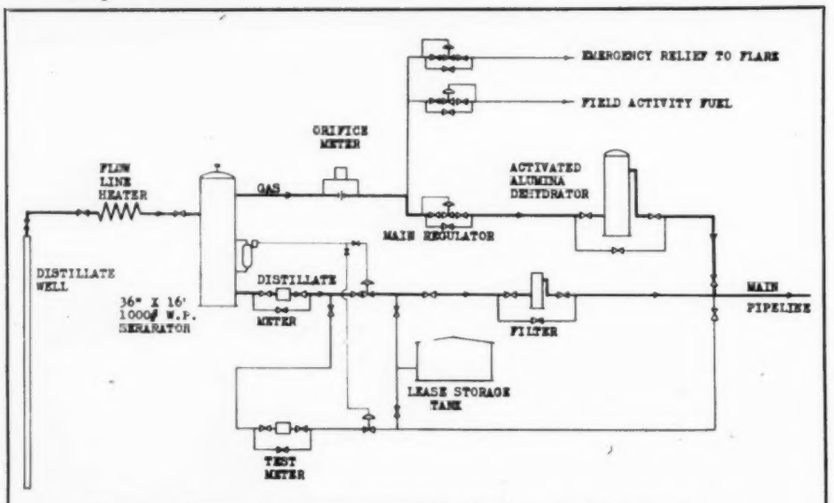


Fig. 2. Schematic arrangement of a single unit of the separators shown in Fig. 1

range, and flow stream from the well is separated into its two components, oil and gas.

With this type of production and a market for the gas produced with the oil, a pipe line was constructed from the Lake Arthur field to the company's Gillis, Louisiana, gasoline plant, to transport simultaneously the oil and gas after each was measured in the field, and after measurement, commingled in the one pipe line.

Experience gained through pioneering with high-pressure, pressure-maintenance operation and deep-well multiple-zone completions, prompted the company to pioneer multiple-fluid pipe line technique; and so far as is known this is the only large scale installation of its type in existence.

Line Operated at Well Pressure

As there was ample wellhead pressure, it was decided to operate the line and the high-pressure recovery equipment at the discharge end of the line under well pressure. The length of the line between the field and the gasoline plant is 27.8 miles.

Equipment for the project consists of high-pressure separators and meters for both gas and oil for each lease, 27.8 miles of 8-in. welded pipe line, and controlled stabilizing equipment at the Gillis gasoline plant. Existing equipment in the gasoline plant had sufficient capacity to handle absorber oil circulation through a new high-pressure absorber and the vapors from the stabilization equipment.

Fig. 1 shows the general arrangement of the high-pressure separators in the field. One separator with its liquid and gas meters is used for each separate producing lease in the field. In Fig. 2 is shown a schematic arrangement of a single unit of the separators in Fig. 1. In this assembly there is a heater between the well and the field separator and it is used to add only a sufficient quantity of heat to prevent freezing of water vapor due to the cooling caused by restricting the well flow by chokes or flow beans. The separator is operated at a pressure that permits condensation of the liquid hydrocarbons, which are removed through the liquid meter shown. Pressure regulation on the oil produced is on the downstream side of the meter. After passing through a suitable filter the oil enters the field end of the dual pipe line. Headers into which the individual lease separators discharge are shown in Fig. 1.

Gas from the lease separator passes through a high-pressure orifice meter for measurement. After metering the gas passes through an activated alumina dehydrator to remove sufficient water vapor to prevent the formation of hydrates and resultant freezing of the main line.

Sensitive pressure regulators are used on both the gas and oil lines between the separators. Proper pressure balance has at all times been maintained without difficulty. Test meter equipment is installed in the battery to insure constant accuracy.

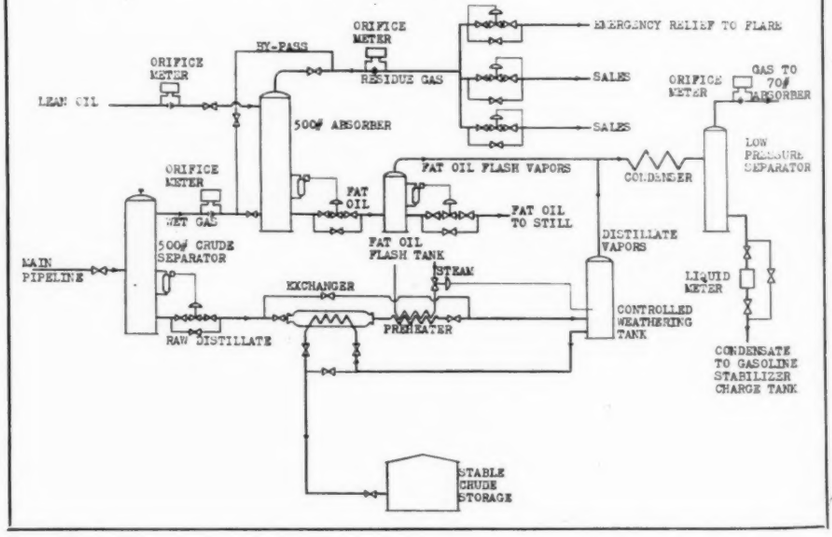
After leaving the field separator battery, the gas and oil flow together through the main line to Gillis, 27.8 miles away. Flow conditions in the line become steady a few hours after field conditions are changed, and pressures taken along the line indicate that the reduction in pressure, due to the mixed flow, is very uniform.

Fig. 3 shows the arrangement of equipment in use at the Gillis gasoline plant for the discharge end of the dual line. Crude oil from the dual line enters a 500-lb. crude separator. After leaving the separator it passes through a heat exchanger and then to the controlled weathering tank (stabilizer). From the weathering tank the crude oil goes to pipe-line storage.

The wet gas from the crude oil separator is measured and then passes through a 500-lb. absorber and from there to distribution as fuel after being metered.

The fat oil from the 500-lb. absorber passes through a 70-lb. pressure, fat-oil flash tank and from these to the fat-oil still. Vapors from the fat-oil flash tank, along with vapors from the controlled weathering tank, pass through a condenser and then through a separator where liquid fractions are recovered and measured. This liquid recovery is then passed to the stabilizer charge tank in

Fig. 3. Diagram showing arrangement of equipment at the discharge end of the line



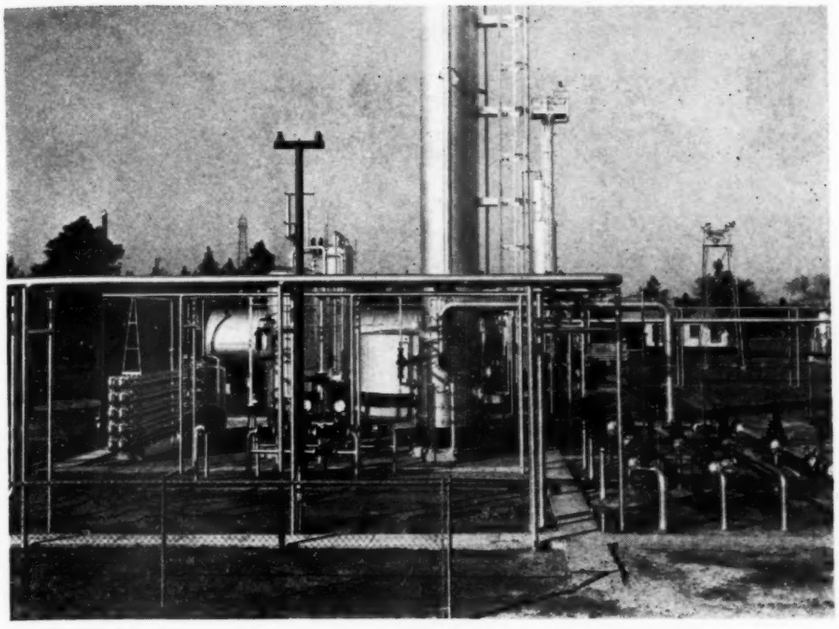


Fig. 4. A general view of Gillis plant

the gasoline plant. Vapors from the low-pressure separator are measured and processed through a low-pressure absorber. Residue from the low-pressure absorber is used for fuel.

Figs. 4 and 5 are general views of the discharge end of the dual line at the Gillis plant.

Design of Pipe Line

In designing a pipe line for the simultaneous handling of oil and gas, the initial and terminal pressures of normal operation must be known or assumed. The total volume of oil alone that may flow through the line of size chosen under the above assumed pressure conditions is then calculated or determined by use of any of the well known oil flow formulae.

Next, the total volume of gas alone that may be handled under the above pressure conditions is determined by use of one of the standard gas-flow formulae. The pipe size determined by this method should be one that will permit at least 20 percent more gas than the total that will be required at any time. Having made these calculations, the barrels of oil alone that may be moved through the line per lb. of pressure drop are expressed in cu. ft. per lb. of pressure drop.

The cu. ft. of gas that may be moved per lb. of pressure drop are next determined from the original calculations. The ratio of cu. ft. of gas per lb. of pressure drop to cu. ft. of oil per lb. of pressure drop is then determined. This ratio is approximately the ratio of friction loss for equal volumes of oil and gas through the line.

The amount of oil that must be moved is assumed known and is converted to equivalent cu. ft. of gas with the above ratio factor.

Subtracting the gas equivalent from the total volume of gas alone that may be handled under the assumed pressure conditions, gives the approximate volume of gas that may be transported along with the oil.

This method of calculation is strictly a rule of thumb method, but experience has proved the answers to be within 10 percent of results obtained with volumes of oil and gas actually moved in practical operation and that the method suffices for most field operating conditions.

The exact computations for combined or mixed flow is extremely complicated as there are many presently unknown variables that enter into the problem. The effect upon the coefficient of friction by gas going into or out of solution with the oil is unknown. The effect of turbulence or condition of flow of two miscible or partially miscible fluids is also unknown. The effect of pressure change due to friction loss will affect the above conditions, as a unit section of the combined stream moves under continuously diminishing pressure toward the discharge end of the line.

Problems of field separation and measurement before oil and gas are put into a single line for simultaneous transportation are well known to the industry and are quite distinct from the problem of transportation.

Experience in the operation of a two-fluid line over more than two years definitely indicates the following advantages:

1. The amount of steel required is greatly reduced and there are many places where such installations could be used to relieve the present steel shortage due to the war emergency.

2. Field separation is simple and practical and pressure control is not difficult to maintain.

3. Discharge terminal separation is handled in somewhat the same manner as field conditions.

4. Difficulties from freezing, due to the formation of hydrates, is readily overcome by dehydration during initial separation.

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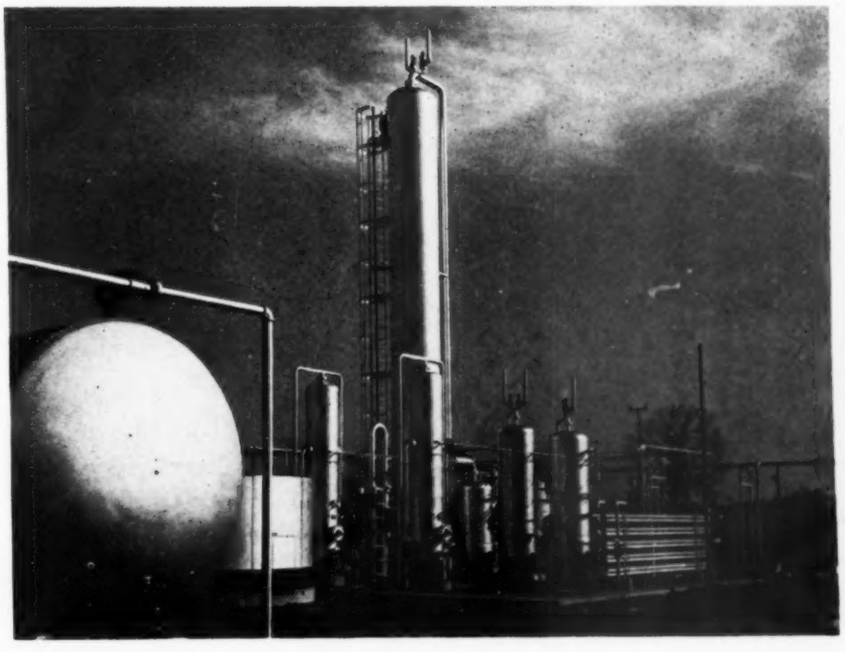
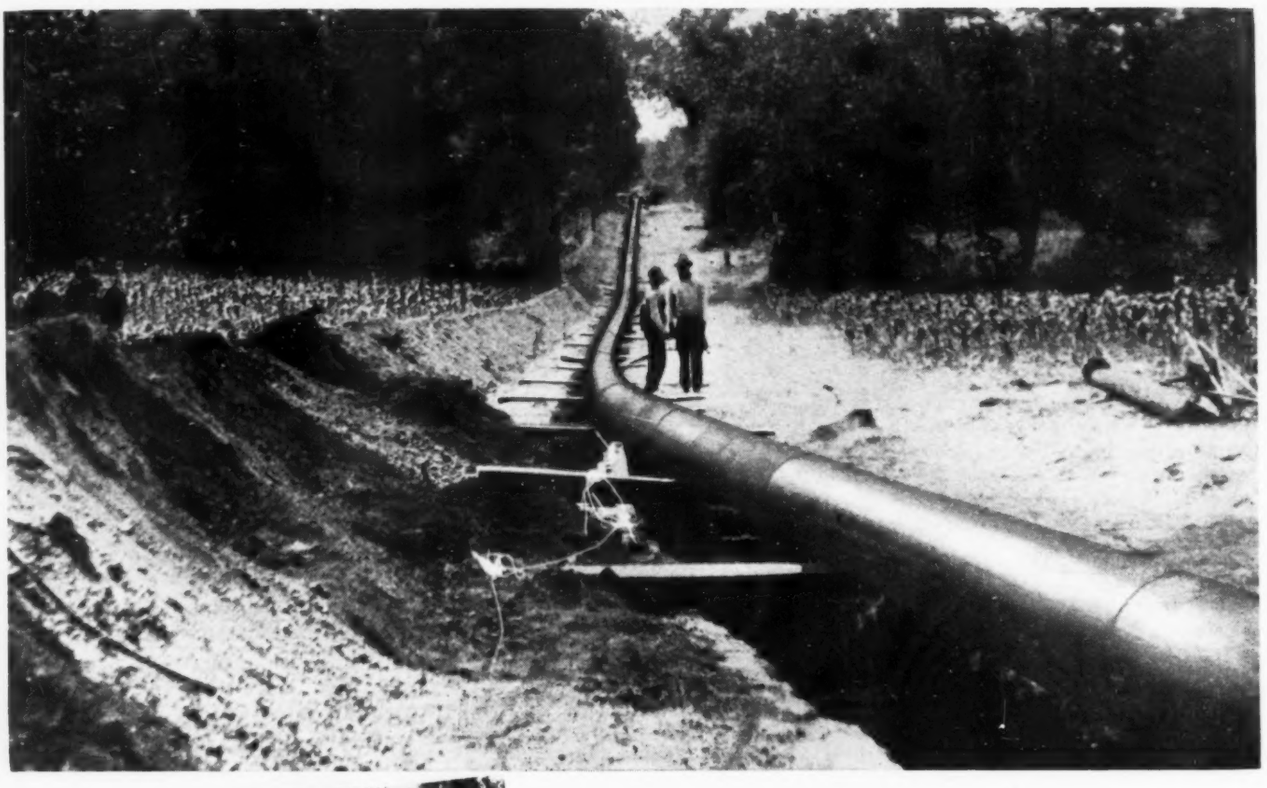


Fig. 5. View of plant on discharge end of line

PARSONS



For extra wide trenches, not too deep, dual booms may be effectively used.

TRENCHERS Lay Direct Paths For Pipe Lines

Parsons digs its trenches for gathering lines in oil field areas in a straight line . . . because a straight line is the shortest distance between two points. This saves time and pipe line material, too. A Parsons Trencher won't be halted by tree stumps, steep banks, or rock terrain . . . because Parsons are known to travel direct. Pipe line excavations can be made with boom in extreme right or left hand positions . . . without sacrifice of speed or ease of operation.

For complete details write The Parsons Company, Newton, Iowa

TRENCHING EQUIPMENT

PARSONS

Pipe Line
P 615.63

Maintenance of Pumping Station Equipment

☆ A well-planned maintenance program is essential for equipment operating under heavy continuous loads

PETROLEUM ENGINEER Exclusive Feature

PART I

by E. R. Spencer

Engineering Department, The Cooper-Bessemer Corporation

DURING the early days of the petroleum industry, the problem of transportation was relatively simple. In 1859 Col. Drake brought in the first commercial oil well on the banks of Oil Creek in Pennsylvania. The oil was produced in wooden kegs, wine casks, and rectangular tanks. From the wells the oil was transported to Oil Creek by teams. At Oil Creek it was loaded on barges and started to market. The increase in production brought greater problems with teamster, mud, and other unfavorable conditions. Conditions grew more difficult until September, 1865, when construction began on the first oil pipe line. The line was made of 2-in. wrought iron pipe and was 5 miles in length. The oil was relayed through two pumping stations. From this early beginning the pipe-line industry has grown to staggering proportions.

Today, the business of gathering crude oil from producing wells and delivering it by pipe line to refineries and marine terminals proceeds in such an orderly and efficient manner that the general public is usually unaware of the importance of this mode of transportation. Oil shipments move quietly through invisible underground systems and other than a few surface buildings and tanks, there is little to indicate that each 24-hour period 3,000,00 bbl. are gathered from 350,000 active oil wells in 20 states and transported by pipe lines to about 500 refineries and marine terminals. About 125,000 miles of pipe line from 2 to 12 in. are in active service, and including all pumping facilities represent a capital investment of $750,000,000 or an average of $6,000 per mile of line in use. Pipe lines vary from a few miles to combination operations in which crude oil is delivered more than 1400 miles from the field in which it was produced. If the daily pipe-line shipments could be handled by rail, it would require about 18,000 tank cars of 8,000 gal. each in a train 130 miles long.

E. R. SPENCER

taught for several years at Texas A. and M. College before joining the staff of The Texas Empire Pipe Line Company as maintenance engineer—In 1934 he was made assistant chief engineer of The Texas Pipe Line Company and affiliated companies, and in 1936 was placed in charge of the company's engineering office in Tulsa, Oklahoma—Since 1941 he has been with The Cooper-Bessemer Corporation in charge of turnkey power plant construction and installation plans—He received B.S. and M.E. degrees from the State College of Washington and pursued post graduate studies while teaching at Texas A. and M. College.

Commensurable with the pipe line growth has come the increase in the use of pumping equipment. The factors governing the power required to move oil through a pipe line varies between wide limits. The number of pumping stations and the amount of machinery in each will, therefore, vary for each individual pipe-line system. An example, however, may serve to give some idea of the enormous amount of machinery required by the industry. One trunk pipe line running from Oklahoma to the Great Lakes, a distance of 900 miles, has a capacity of 90,000 bbl. per day. This line requires approximately 40,000 hp. in pumping machinery, which is divided among 18 stations.

Assuming that the above is representative of all pipe lines, one can readily realize the tremendous amount of machinery involved in the oil transportation industry. As machinery in pipe-line service operates under heavy continuous loads, it is subject to rapid wear and deterioration. Consequently, the maintenance of this machinery is vitally important to the transportation of oil. In turn, the importance of machinery maintenance calls for detailed and well-planned procedures for both large and small operations. With this thought in mind the following is offered as a possible aid to those interested in this field.

Station Maintenance

As space does not permit a detailed discussion of more than few of the major factors involved in maintenance, remarks will be confined to general principles with only a brief resumé of a few outstanding maintenance procedures. The main objects of any maintenance program, as applicable to pumping stations, are:

(1) To keep equipment in serviceable condition.

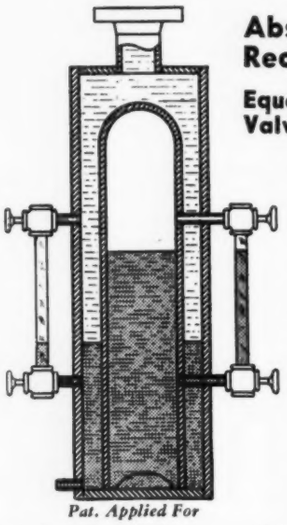
(2) To reduce emergency shutdowns to an economic minimum.

(3) To keep the cost of such maintenance within reasonable economic limits.

The most important asset to any pump station maintenance program is a complete and comprehensive record of each piece of mechanical equipment. Due to this requirement, it becomes necessary to establish some form of periodic report, one that will indicate every maintenance operation performed on the particular equipment during a specified period. Table 1 is one form of such record. Obviously, this particular chart contains information for a main line Diesel reciprocating type of equipment. Similar record forms can be adapted to any particular type of ma-

When it Comes to Pipelines— Come to Wheatley

EQUALIZERS
—Liquid Seal



Absorbs Shock on Reciprocating Pumps

Equalizes Pressure on Lines, Valves and Cylinders

Incorporates the best features of the conventional air chamber but eliminates the objectionable characteristics. Air or gas cannot escape into the line because the sealing liquid is inert to absorption of air or gas from the compression chamber. The liquid is also insoluble in and of higher specific gravity than the liquid being pumped. Minimizes tendencies toward corrosion and gum forming in the lines. Eliminates danger of explosion when air is used in compression chamber. May be used at all operating pressures common in petroleum pipe line industry.

Pat. Applied For

- Simple in Principle
- Compact in Design
- Easily Installed
- Rust and Corrosion Proof
- Relieves Shock on Other Equipment
- No Moving Parts
- Nothing Wears—Nothing Tears
- Nothing to be Replaced
- Available for suction and discharge side
- Made in any size
- Available for Immediate Shipment

Outstanding features and efficiency proved by major pipe line under actual operating conditions.

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PUMPS—*The Most Unique Line*

For Instance—

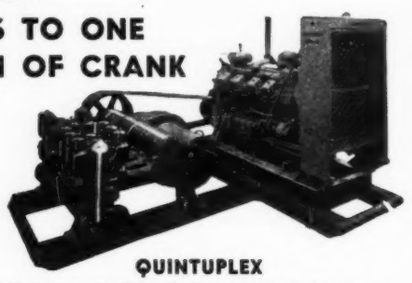
10 IMPULSES TO ONE REVOLUTION OF CRANK

LESS SURGE

LESS WEIGHT

MORE VOLUME

MORE PRESSURE



QUINTUPLEX

5 Cylinder, 5¾" x 8", Fig. 5850—8300 lbs. Wt.

CAPACITY

Figure	Liner	Gals. Per Min.	Bbls. Per Hour	Pressure Per Square Inch	Max. H.P. Req'd
	3"	182	260	1605	200
5¾"x8"—V-Belt	3½"	257	367	1137	200
Fig. 5850	4"	344	492	850	200
Five Cylinder	4½"	442	632	658	200
85 R.P.M.	4¾"	495	707	590	200
Steel Fluid	5"	552	789	529	200
Cylinders	5½"	673	961	434	200
	5¾"	735	1050	396	200

DUPLEX

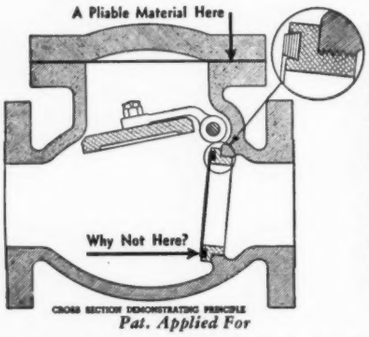
Power driven, reciprocating, with interchangeable liners, Herringbone gears Direct or V Belt Driven.

2½" x 4" x 6"
2½" x 6" x 6"
2½" x 5" x 10"
2½" x 7" x 10"
2½" x 8" x 10"

Pressure from 190 lbs. to 1500 lbs. Capacities from 69 B.P.H. to 729 B.P.H.

Write for Bulletin E32

CHECK VALVES
—Exclusive Synthetic Rubber Seal



Pat. Applied For

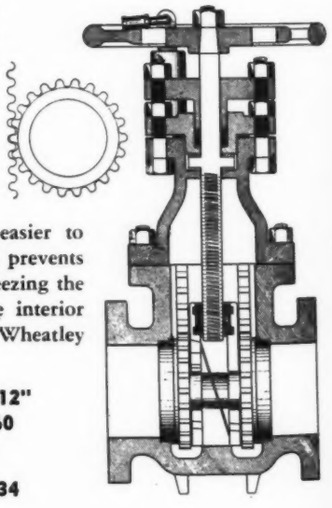
Equipped with Wheatley Synthetic Seal—a synthetic rubber ring dovetailed and fitted into a removable bronze seat. A perfect seal is formed regardless of what irregularities have deposited on the seat or in the fluid, such as sand, scale and cuttings which under pressure ordinarily would completely cut out a hard-surfaced seat.

- The rubber ring conforms to all deposits and obstacles and makes it possible for this valve to seal under the worst conditions.
- Seals regardless of viscosity. Operates equally well on kerosene or crude.
- No lapping or grinding of seats necessary.
- Absolutely silent in operation. Ideal for refineries and pumping stations where the slapping of metal check valve clappers is annoying.
- Renewable bronze seat ring, into which the rubber ring is inserted, can be replaced by the standard metal to metal seat, if desired.

Write for Bulletin E33

GATE VALVES
—Self-Cleaning Rack-Type

This Gate Valve is of the rack type construction, which means the Gate Discs have teeth identical to gears and are so designed that they run up a rack (see diagram) which is cast in the body of the valve.



This construction makes it easier to open and close the valve and prevents any foreign materials from freezing the operations of the valve. The interior working parts are cast of Wheatley Special Bronze.

Made in Sizes 2" to 12"
Series 15- 30- 40- 60
Iron, Steel, Brass

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- TAPPING MACHINES
- RIVER CLAMPS
- HALF SOLES
- PLUG VALVES
- WELDING SLEEVES
- STRAINERS
- STERLING CENTRIFUGAL PUMPS

W WHEATLEY PUMPS *and* VALVES

TULSA OKLAHOMA

chinery involved in pump station operation. The details of the itemized information and the detailed form on which it is kept will, of course, be governed by conditions, ownership policies, and equipment involved.

It will be noticed that Table 1 supplies general information regarding the mechanical conditions but does not go into the cause and correction of any given failure. It is, therefore, necessary that some means be provided to report in detail all circumstances and conditions surrounding each individual mechanical failure if proper analyses are to be made. Table 2 represents one way of procuring and recording these necessary data and information. A study of some such form of failure record is vital in detecting weak or troublesome parts of a given piece of machinery. It also provides a basis for improvement of such features as design, material, operating practice, etc.

Although the quantities of fuel and lubricating oil used by prime movers are primarily operating details, the maintenance men should be familiar with these values. A comparison of these quantities, reduced to some equitable unit, is very helpful in predicting general mechanical condition. The unit used as a basis for such study will be best determined by the type of machinery, general accounting system used by the owner, and the duty performed by the machinery. The following are a few of the many units to which fuel consumption may be reduced:

(1) Pounds of fuel per hour of operation.

(2) Pounds of fuel per bbl. of oil pumped.

(3) Pounds of fuel per hydraulic horsepower hour.

(4) Pounds of fuel per rated horsepower hour.

Similarly, a few of the basic units for lubricating oil consumption are:

(1) Gallons of lube per bbl. pumped.

(2) Rated horsepower hours per gal. of lube.

(3) Hydraulic horsepower hours per gal. of lube.

(4) Gallons of lube per hour of operation.

As stated, the condition will, to a large extent, dictate which units are to be used.

The individual in charge of maintenance should also have a rather detailed knowledge of costs. The compilation of such costs will be governed by general policies of the plant owner. Regardless of when or where the records are kept, the maintenance supervisor should know the cost of both labor and material chargeable to each repair. This knowledge provides a basis for an economic study of maintenance procedure. Costs, together with other records, supply the information necessary to the development of less costly repairs. Obviously, it is impossible to know the economic status of a given method of repair procedure unless something is known about its life, serviceability, dependability, and cost.

The importance of adequate records cannot be over-stressed. Regardless of whether they are elaborate or meager, they should be kept accurately. The matter of future value should always be uppermost in the minds of those who compile pump station maintenance reports and data. The following discussion will continually refer to the information compiled as a basis for certain decisions.

Stocks of Repair Parts

The necessity for a stock of repair parts is obvious if the continuity of service is to be assured for all equipment in a given plant. Listed below are a number of the more important factors that affect the quantity of repair parts to be kept on hand.

(1) Plant operating factor.

(2) Cost of out-of-service time.

(3) Distance from source of material, and manufacturer's ability to supply.

(4) Different types of equipment.

(5) Frequency of certain failures.

(6) Plant location.

(7) Division or district warehouses.

(8) Advantages in quantity purchases.

TABLE I

Convenient form on which to make maintenance report

John Doe - Type ZK-Vertical 600 H.P. 5-K-25m — EXHIBIT "A"

ENGINE MAKE & NO. No. F155E54 PUMP MAKE & NO. Move-more 6-3/4 x 24 Hor. Trip. No. 525699

MECHANICAL MAINTENANCE REPORT

STATION Pumpkin Center Ridge UNIT NO. 1 DATE February, 1930

			CYL. No. 1	CYL. No. 2	CYL. No. 3	CYL. No. 4	CYL. No. 5	CYL. No. 6
MAIN CYLINDERS	CYLINDER HEAD	Condition Repaired or Replaced	Good	Good	Good	Good	Good	
		Head Clearance Before and After Adj.	.368 .360	.355 .370	.360 .370	.345 .376	.364 .364	
		Compression Pressure Before and After Adj.	485 485	475 490	477 487	486 490	496 496	
	LINER	Condition Repaired or Replaced	Good	Good	Good	Good	Good	
		Measurement at With Pin	17.521	17.524	17.525	17.520	17.516	
		Top of Ring Travel Crosswise of Pin	17.521	17.519	17.519	17.513	17.516	
		Measurement at With Pin	17.508	17.506	17.508	17.507	17.507	
		Lower Ring Travel Crosswise of Pin	17.508	17.507	17.508	17.505	17.507	
	PISTON	Condition	Good	Good	Good	Good	Good	
		Number of Rings Found Stuck	2	2	3	3	2	
		Number and Size New Rings	5- 17 x .371	5- 17 x .371	5- 17 x .371	4- 17 x .371	4- 17 x .371	
	CROSSHEAD PIN OR PISTON PIN AND BEARING	Pin Wear (Out of Round)	.001	.005	.002	.004	.001	
		Repaired or Replaced (Diameter)		Ground		Ground		
		Condition of Bearing	Good	Broken	Good	Broken	Good	
		Repaired, Replaced, Clearance	.002	Rerun .00		.002 Rerun .002	.002	
	EXHAUST VALVE AND CASING	Condition Valve and Seat	Good	Good	Good	Good	Good	
		Cleaned and Repaired, Show Date	2-11-28	2-11-28	2-11-28	2-11-28	2-11-28	
	INTAKE VALVE AND CASING	Condition Valve and Seat	Good	Good	Good	Good	Good	
		Cleaned and Repaired, Show Date	2-11-28	2-11-28	2-11-28	2-11-28	2-11-28	
	SPRAY VALVE	Condition Valve and Seat	Good	Slightly Carbored	Good Fair	Good	Slightly Carbored	
		Timing Found—Degrees Open & Close	6°BTC 36°ATC	6°BTC 36°ATC	6°BTC 36°ATC	6°BTC 36°ATC	6°BTC 36°ATC	
		Timing Set—Degrees Open & Close	6°BTC 36°ATC	6°BTC 36°ATC	6°BTC 36°ATC	6°BTC 36°ATC	6°BTC 36°ATC	
		Valve Lift—Before and After Adj.	.125" .146"	.121" .150"	.115" .146"	.125" .150"	.119" .147"	
		Repaired, Reground or Renewed Date	2-11-28	2-11-28	2-11-28	2-11-28	2-11-28	
	STARTING VALVE	Condition When Inspected	-	-	-	Good	Good	
		Cleaned, Ground or Renewed	-	-	-	2-11-28	2-11-28	
	FUEL PUMP AND FUEL PUMP VALVES	Condition Pump Valve Body	Good	Good	Good	Good	Good	
		Check Valves—Ground or Renewed	Ground	Ground	Ground	Ground	Ground	
		Plunger—Repaired or Renewed	-	-	-	-	-	
		Discharge Valves—Ground or Renewed	Ground	Ground	Ground	Ground	Ground	
		Suction Valves—Ground or Renewed	Ground	Ground	Ground	Ground	Ground	
CRANKSHAFT AND CRANKSHAFT BEARINGS	MAIN BEARINGS	Condition Before & Clearance	.008 .008	.012 .008	.010 .007	.007 .007	.008 .009	.009 .009
		After Adj. Level	Level	Level	Level	Level	Level	Level
		Reset or Renewed	-	-	Bottom shell cracked	-	-	-
		Bridge Gauge Crankshaft Free & Clamped	18.175 18.176	18.056 18.057	18.057 18.056	17.909 17.910	17.970 17.971	18.011 18.012
	CRANK BEARINGS AND PINS	Clearance—Before & After Adj.	.010 .007	.008 .008	.010 .007	.009 .008	.008 .008	
		Reset or Renewed	Reset	Reset	Reset	Reset	Reset	
		Crank Pin Condition	Good	Good	Good	Good	Good	
	DISTANCE BETWEEN CRANK WEBS	Crank at Top Dead Center	.398 .398	.155 .155	.429 .429	.216 .216	.240 .240	
		Crank Horizontal—Down Stroke	.397 .397	.155 .154	.428 .428	.215 .215	.239 .239	
		Crank at Bottom Dead Center	.396 .396	.154 .153	.428 .428	.214 .214	.238 .238	
		Crank Horizontal—Up Stroke	.397 .397	.155 .154	.428 .429	.215 .215	.239 .239	
OTHER BEARINGS	CAM SHAFT	Condition—Reset or Renewed	Good condition - All bearings checked			REMARKS Pump center crank web readings		
	Vert. or Lay Shaft	Condition—Reset or Renewed	Good Top .017 Adj to .014 Bt .016 Adj to Before Adj.				After Adj.	
	OUTBOARD BEARING	Condition and Level	Before Adj. Level	After Adj. Level .005		A-Top 6.017	6.015	
		Bearing Reset or Renewed—State Clearance	Before Adj. .008"	After Adj. .008"		B-Hor. down stroke 6.018	6.015	
	END THRUST IN ENGINE	Crankshaft	Before Adj. .011"	After Adj. .011"		C-Bottom 6.017	6.015	
		Camshaft	Before Adj. .008"	After Adj. .008"		D-Hor. up stroke 6.015	6.015	
		Vertical Shaft	Before Adj. .008"	After Adj. .008"				
GOVERNOR		Cond., Rods, Pins, Bearings	Renewed Anchor Pins and Bushings					
		Note Adjustment or Replacements	Before Adj. .014	After Adj. .014				
		Gear Clearance						
		Camshaft Gear Clearance—Top & Bottom	Before Adj. .010 - .012	After Adj. .010 - .012				

		HIGH STAGE	INTER STAGE	LOW STAGE
COMPRESSORS	PISTON AND LINER — Condition—Replacement	Good	Good	Good
	Head Clearance—Before & After Adj.	1/16 1/16	5/16 5/16	7/16 7/16
	Max. Liner Dia.—Purp. & Par. to Crank	8.7[illegible] 8.756	10.7[illegible] 10.75[illegible]	17.47[illegible] 17.47[illegible]
	RINGS — Number, Found Stuck, Replaced	None 0	1 1	None 4
	SUCT. VALVES DISCH. VALVES AIR COOL COILS — Cleaned, Ground, Renewed, Show Date	2-10-28	2-10-28	2-10-28
	Cleaned, Ground, Renewed, Show Date	2-10-28	2-10-28	2-10-28
	Unload, Repaired, Renewed, Show Date	2-10-28	2-10-28	2-10-28
	Pressures Last Day of Month	900# LEFT	120# CENTER	60# RIGHT
MAIN PUMP	MAIN BEARINGS — Levels—Condition			
	Renewed, Repaired or Adjusted			
	PINION BEARINGS — Levels—Condition			
	Renewed, Repaired or Adjusted			
	CRANK PIN BEARINGS — Condition			
	Renewed, Repaired or Adjusted			
	CROSSHEAD AND PIN BEARINGS — Renewed, Repaired or Adjusted			
	Crosshead Adjusted or Repaired—Cond.			
	PUMP CRANKEDS — Renewed or Repaired			
	PUMP HEADS — Clearance—Before & After Adj.	LEFT SIDE	RIGHT SIDE	
	Condition—Before & After Adj.			

		Left Crank	Left Crank	Center Crank	Center Crank	Right Crank	Right Crank
	PLUNGERS — Condition						
	Renewed or Repaired						
	Packed—Kind & Date						
	VALVES AND SEATS — Condition						
	Repaired or Replaced						
	COUPLING — Clearance	Top	Quarter	Bottom	Quarter		
	Alignment	Vertical		Horizontal			

MISCELLANEOUS	DATE BOLTS TIGHTENED AND INSPECTED — Foundation	Engine	Pump
	Frame		
	Others		
	IDLER GEAR BEARING — Bearing Reset or Renewed		
	Gear Clearance & Cond.		
	LUBRICATING SYSTEM INCLUDING PUMPS — Piping Cleaned & Inspected		
	Lubricator Cleaned & Inspected		
	When Circulating Pump Required		
	WATER JACKETS — Date Most Washed Out and Condition — Main Cylinder	2-10-28 Soft Muddy Scale	
	Cylinder Heads	2-10-28 Thin Scale	
	Exh.—Manifold Center	2-10-28 O.K.	

FORCED SHUTDOWNS—ENGINE AND PUMP			REMARKS	
Date	REASON	Hrs.	This unit ran 17,429-2/4 hrs. between overhauls 6-1-26 and 2-1-28 - Total 1 yr. 7 mo.	
1	Down for General Overhaul			

OPERATING DATA	
Accumulative Hours Run	24,410
Hours Operated During Month	428
Hours Run Since Last Complete Overhaul	428
Date of Last Overhaul	February 1-11,1930

The operating factor on pumping stations varies between wide limits. For instance, certain stations may require the continuous operation of all pumping units whereas others may be able to handle the load with only a small part of the installed machinery operating part-time. It is apparent that shutdowns directly affect revenue when operating under the former conditions. In this case it is important that a larger supply of spare parts is readily available. On the other hand, where the operating factor is low, it may be that delays in the making of repairs can be tolerated because the revenue to the owner is not affected.

If the plant is far removed from the source of supply, much delay can be expected. A more serious consideration in this connection, however, is the manufacturer's ability to supply parts on short notice. Obviously, if the manufacturer, for any reason, cannot ship parts promptly from stock, repairs will be slow and operating time lost.

The matter of different makes and types of machinery in a given plant is perhaps one of the most dominant factors in the problem of spare part stocks. In a plant requiring a high operating factor the stock of repair parts required is approximately proportional to the number of different types of equipment installed. The reason for this condition is evident.

Certain parts on each type of pump station machinery fail more often than others. This fact often complicates the spare parts problem; authentic records will provide the best solution. If the plant is isolated and a long way from other similar plants, larger repair stocks are necessary. In some organizations district or division warehouses have been established. These control stocks are set up to serve the machinery in several pumping stations. This, of course, has a tendency to keep the total stock inventory lower than required when each station is regarded as an independent unit. For apparent reasons there are often price advantages to be gained by ordering various materials in relatively large quantities. This will often affect the number of a given part kept in stock.

From the above brief discussion, it is evident that the matter of spare machinery parts presents a rather complex problem. It is, however, possible to arrive at an economical solution through a study of local conditions and an analysis of adequate maintenance records.

The ordering and storing of spare parts should, by no means, be a haphazard arrangement. When all factors, data, and other information have been considered, make a list itemizing each part that is to be placed in stock. Show on this list the maximum and minimum number of each item to be stored. Keep a perpetual inventory of each item. When the stock has been depleted to the minimum number, bring it up to the maximum by placing an order for an additional supply. This, or similar procedures, will eliminate the possibility of running out of any one item, which would cause delay and loss of time. It will be necessary from time to time to adjust the itemized stock list as well as the maximum and minimum number of each item carried in stock to conform to changing conditions.

Machinery parts are expensive and the storage of such equipment is important. A definite place for storage should be provided, one having plenty of light. Make it of sufficient size to enable the attendant to keep it clean and in order. Provide in this room ample shelves and racks to accommodate all parts. Each part should have its place where it is protected from damage. Much care and thought should be given to the design of these bins and racks. Do not pile up metal parts as they will scar and scratch each other. These scars and scratches will quite often render the part unserviceable. The matter of warpage also must be considered when providing storage space. Many parts are of thin cross-section and will deform when allowed to lie in certain positions for any length of time. For instance, a trunk type piston, if allowed to lie on its side for any appreciable amount of time will warp. Its skirt will become elliptical. Such parts should be stored standing on end. Valves with long slender stems are also subject to warpage; when laid down and permitted to remain in this position, the stems deform and become useless. One common and effective method of storing valves and similar parts having slender cross sections is to make a rack or table top having holes of proper size through which these parts can hang freely. Thus, the importance of properly designed storage equipment is evident. All materials should be greased, wrapped or otherwise protected from moisture and other deteriorating agencies. Attach a durable tag to each part bearing sufficient information so that it can be identified readily and accurately.

The source of supply for machinery parts is one that can be determined only after much thought and study. It is natural to believe that the manufacturer of a given machine is best equipped to make repairs for it. Many conditions, however, influence this situation. The manufacturer may be situated so far away that it is to the owner's advantage to have certain parts made locally. Extreme care, however, is necessary when attempting to procure machine parts from local shops. Make sure that the shop has the equipment that will make possible the machining of parts to the required tolerances. The metal used in making new parts is of vital importance. No attempt should be made at making machine parts without a thorough knowledge of the physical and metallurgical requirements.

Editor's Note: This article will be continued in an early issue of *The Petroleum Engineer*.

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TABLE 2

Mechanical breakage report

DESCRIPTION OF EQUIPMENT INVOLVED Exhaust valve cage on "Whip Special" Diesel Engine — 900 hp., Type XYZ, No. 489, 4-cylinder.

WHAT HAPPENED Upon investigating loud leakage of exhaust gases and loss of power in the engine, on exhaust valve cage on No. 4 cylinder was found broken between the spring housing and the bolt hole in the fastening lip of the cage.

CAUSE The breakage is attributed to uneven tightening of the cage together with too much force on the nuts that hold the cage in its port.

HOW REPAIRED Installed new exhaust valve cage and gaskets.

STEPS TAKEN TO PREVENT RECURRENCE When tightening valve cages great care is emphasized to make sure that the nuts are tightened with the proper wrench using no wrench extension. Soft compressible gaskets will be used in order to prevent leakage without excessive tightening of the cages.

COST OF REPAIRS: Labor $X.00 Material $XX.00

Date report made 2-27-37 Station Pinley Hill Station

Date break occurred 2-25-37 By B. H. Johnholtz, Engineer

This "Carrot" means healthy metals

YOU CAN SEE why metalworkers call this lump of calcium metal a "carrot." This is the way it looks when it comes from an electrolytic cell in which it is made.

Calcium is a soft, silvery-looking metal. Although it is abundantly present in such common materials as chalk and limestone, its recovery as a pure metal is extremely difficult. Yet it is vitally essential to this country.

In the making of stainless or high-alloy steels, calcium drives out impurities, giving cleaner, better steel for casting or rolling. In magnesium casting, small amounts of calcium improve the finish of the surface and minimize scaling. Calcium is an essential in the making of many metals.

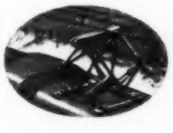
This hitherto rare metal has been made in this country only during the past few years. Before Europe exploded, the United States was dependent upon France as a source of supply.

But back as far as 1935, thinking that this country should have a domestic source, ELECTRO METALLURGICAL COMPANY, a unit of UCC, started a major research program. After four years of work . . . as French supplies dwindled . . . a plant was put into operation for the manufacture of the gray metal. Today, ELECTRO METALLURGICAL COMPANY produces many times as much calcium metal as this country ever imported . . . and production is increasing.

IN THE AIR SOONER! Vital aircraft parts flow from production lines quicker because the use of calcium metal results in better metal.

BETTER HEALTH! Pure calcium metal is used as a drying and purifying agent in the manufacture of certain new disease-fighting drugs.

CHEMICAL HELPER! Calcium is necessary in making a number of rare metals—many of which heretofore were unavailable commercially—and all of which are vital.



METAL-SAVER! In the melting of copper scrap for use in certain types of electrical equipment, calcium is used as a purifier and a restorer of electrical conductivity.

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Welding Technique for Pipe-Line Construction and Repair

PETROLEUM ENGINEER Exclusive Feature

☆ "Stove-pipe" welding in general use because of its simplicity, speed, and economy—Methods used in making line repairs

by C. M. Taylor
Vice-President, The Lincoln Electric Company

THE NORMAL rapid rate of increase in shielded arc welding for cross-country pipe-line construction has been even further accelerated in recent months by the critical problem of transporting petroleum products, a problem that has resulted in a tremendous demand for more miles of pipe lines to carry petroleum products essential to the war effort.

Due to the simplicity, speed, and economy of "stove-pipe" welding, this method continues to be generally favored by contractors who are now "stove-piping" even the larger sizes of pipe such as 24-in. and 26-in.

Although the "stove-pipe" method is being used for lines over all kinds of terrain, it is particularly advantageous where rough difficult country must be traversed.

One joint at a time is position-welded to the line, thus permitting a reduction in size of crew (particularly desirable in view of the manpower shortage), less equipment, and the advantage of confining operations so that they may be supervised under one head.

Joints for the "stove-pipe" method are usually plain end without liner and position-welded like bell-hole joints. A line-up clamp or "grasshopper" is ordinarily used to hold the joint in place during alignment and tacking. Figs. 1 and 2 illustrate welding of plain end joint with and without liner.

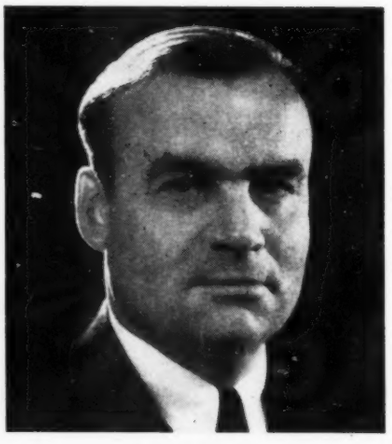
The first of three beads is made by two bell-hole welders working downward from the top simultaneously on both sides of the joint.

For water crossings the wall thickness of the pipe is from 50 to 100 percent greater than that used for the rest of the line. A survey of a number of recently completed lines shows that sections used for such water crossings are "firing-line" or roll-welded. Joint reinforcements for such sections are generally effected by welded-on sleeves. Special river clamps, 4 to 10 ft. long and weighing up to 3000 lb., are often bolted to the pipe at intervals to serve as anchors. Tractors are used to pull the completed section onto pontoons from which it is guided by stakes into a dredged-out ditch in the river bottom.

Some contractors have found it advantageous to use both "stove-pipe" and "firing-line" construction on some jobs — particularly when extremes in terrain conditions must be met.

Tables 1 and 2 give particulars and comparison of "firing-line" and "stove-pipe" methods of welding.

During 1942, one of the foremost electric-welding contractors* completed 14 separate jobs that totaled more than 1000 miles of pipe line. It is interesting to note that the "stove-pipe"



C. M. TAYLOR

graduated from Western Reserve University in June, 1916—Went to work for The Lincoln Electric Company immediately following graduation and remained until the summer of 1917, when he entered the Air Corps Service—Returned from government service in January, 1919—His first position was as clerk in the production department, then time study department, assistant superintendent, superintendent, and in 1928 vice-president in charge of sales—Serves on the board of directors of The Lincoln Electric Company.

*H. C. Price Company, Bartlesville, Oklahoma.

Fig. 1. Plain end joint with liner, used almost exclusively for gas lines. Most economical in larger size pipes and offers negligible resistance to flow. Requires two welding beads

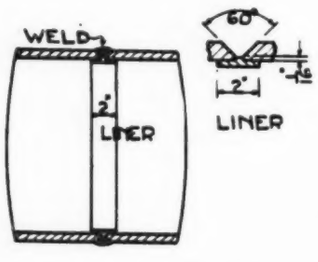
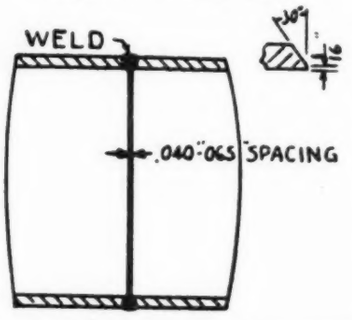
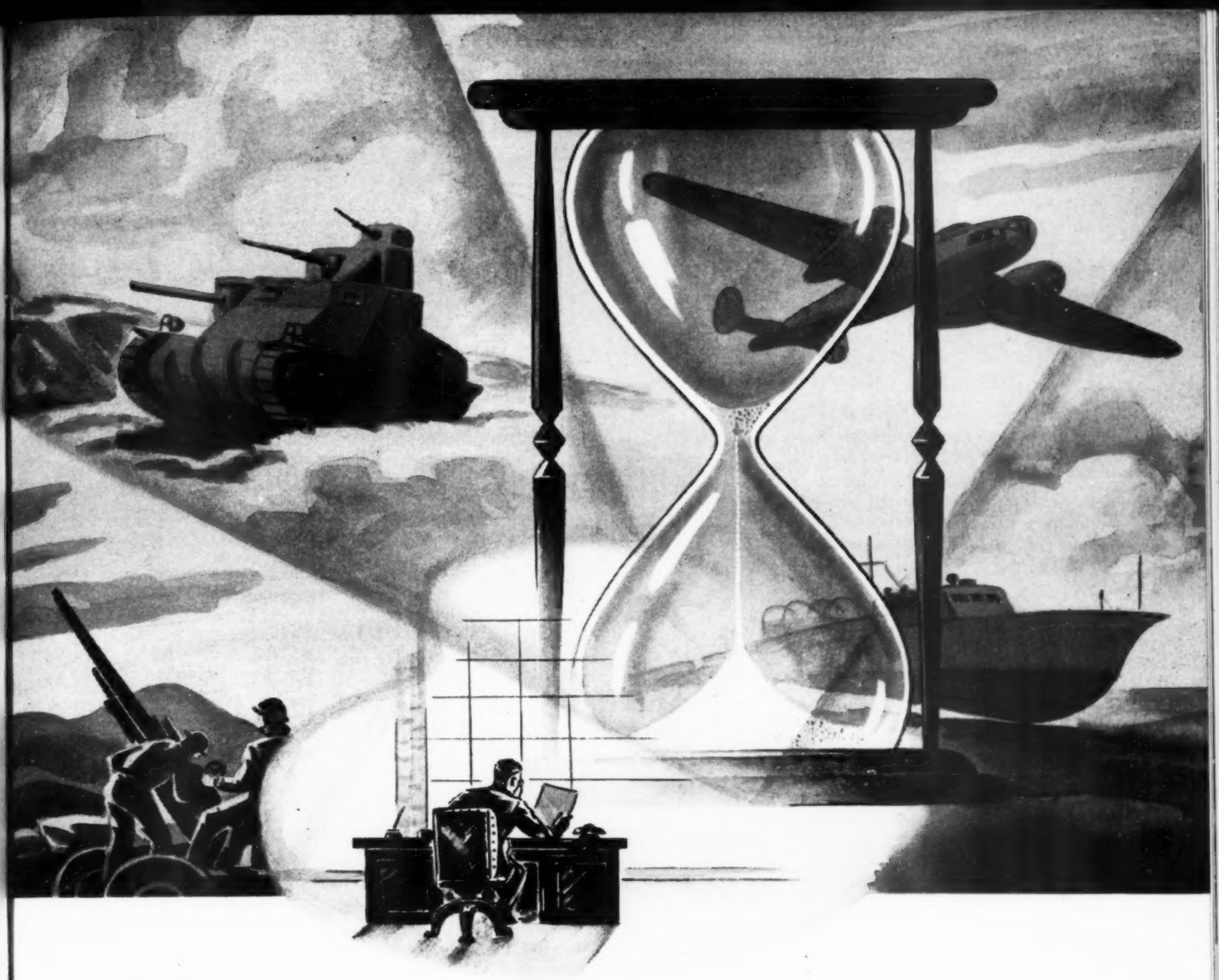


Fig. 2. Plain end joint without liner, used extensively for oil lines up to 26 in. Requires two welding beads.





MESSAGE TO A PEACETIME CUSTOMER

Little more than a year has passed since Pearl Harbor. A single grain in the sands of time — an infinity in the changes it has wrought in the daily lives of all of us.

Little more than a year ago you could sit at your desk, telegraph or telephone an order for Gaso Pumps and just about write your own ticket on delivery. No restrictions — no priorities — no limitations on your activities or demands.

Now, in little more than a year, a mighty nation has been welded into an invincible team pushing its way slowly toward the goal posts of victory. Uncle Sam is calling the signals. We are carrying the ball. Practically all of Gaso's facilities are now engaged in war work.

Why, under such conditions, do we continue the messages which for 25 years have been addressed to you through the oil publications . . . . . .

. . . Because we want you to remember us just as we are remembering you.

. . . Because we want you to know that the closing shot of this all-important struggle will find us back at the old stand, ready, willing and eager to resume our service to peace-time friends.

. . . Above all, because we want you to know that we appreciate your part in lifting us from obscurity to leadership in the field of oil-industry pumps — and plan to repay you with post-war pumps that reflect the expanded facilities and broadened experience of war-time operation . . . Gaso Pump & Burner Mfg. Co., 902 E. First Street, Tulsa, Oklahoma. Export Office: 149 Broadway, New York. Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.

GASO PUMPS

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method of welding was used for approximately 54 percent of this total.

Table 3 gives further particulars on these 14 pipe construction projects.

Of the total number of miles of pipe line welded by this contractor, 503 miles, or approximately 49.2 percent, transport gasoline; 275 miles, or 26.9 percent, oil; 214 miles, or 20.9 percent, natural gas, and 29 miles, or 2.8 percent, water.

Pipe-Line Repair

The acute shortage of new pipe has brought about an acceleration in the reuse of old pipe and reconditioned pipe.

The following welding procedure has proved very satisfactory and reconditioning may proceed while the line is kept operating under normal pressure: First, the line is dug up, a section at a time (see Fig. 3). Sections ranging in length from a few hundred feet to a mile or two are uncovered at one time, depending upon the length of the line to be reconditioned, the terrain, etc. On long lines, where a mile or two of pipe can be raised at one time, several crews of welders can work on that section.

All dirt, rust, and scale are then removed from the pipe. One type of cleaner is a device that wraps around the pipe and by hand operation is rotated and moved along the pipe, scraping off all foreign material. When long sections of line are uncovered and are worked on by several crews, a gas-engine-driven cleaning machine that rides on the pipe is generally employed. To insure the pipe being perfectly clean it is often washed with gasoline after the scale and rust have been removed.

Careful inspection, aided by a point-

TABLE 1

Recommended sizes of electrode for pipe-line welding

Size, in.	Firing line (roll-welding) without back-up ring			Firing line (roll-welding) with back-up ring		Position welding without back-up ring, "stove-pipe" or "tie-in" method		
	Stringer bead, in.	Second bead, in.	Third bead, in.	Stringer bead, in.	Second bead, in.	Stringer bead, in.	Second bead, in.	Third bead, in.
4	5/32	3/16	1/4	.....	.....	.....	.....	.....
6	5/32	3/16	1/4	3/16 or 7/32	1/4	5/32	5/32 or 3/16	3/16
8	5/32 or 3/16	3/16 or 1/4	1/4	7/32 or 1/4	1/4	5/32	5/32 or 3/16	3/16
10	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	1/4 or 5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
12	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	1/4 or 5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
14	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
16	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
18	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
20	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
22	5/32 or 5/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
24	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
26	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 5/16	5/16

For position welding with back-up ring use 3/16-in. rod for all beads on all sizes of pipe.

Note: In the above table the size of the electrode for the first bead depends upon spacing. Size of electrode for second and last beads depends upon thickness of pipe. Use 5/16-in. electrode on additional beads when necessary.

TABLE 2

Average speeds for shielded-arc welding

Size, in.	Firing-line (roll-welding) without back-up ring	Firing-line (roll-welding) with back-up ring	Position welding without back-up ring
	Average number welds per hour	Average number welds per hour	(After first bead run by tackers) Average number welds per hour
6	6.0	7.0	5.0
8	5.5	6.5	4.0
10	4.0	5.0	3.0
12	3.0	4.5	2.0
14	2.75	4.0	....
16	2.5	3.5	....
18	2.4	3.25	....
20	2.25	3.2	....
22	2.1	3.1	....
24	2.0	3.0	....
26	1.8	2.5	....

Fig. 3. Reconditioning a 10-in. oil line in Texas, about 20 years old. Many corroded spots leaked. Welded with two passes 3/16-in. and 1/4-in. shielded-arc electrode.

This Year Rubber Is Tapped from Test Tubes

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Our engineers have been working with synthetic rubber since 1921. During this period they have learned that no one synthetic should be used for all types of mechanical rubber goods. They have found where and how synthetic is superior to natural rubber, where it is equally as good, where it falls short. They know what uses each of the five basic commercial types of synthetic rubber is best suited for — Neoprene, Buna-S, Buna-N, Butyl, or Thiokol—and how to compound the specific synthetic rubber for the specific task. U. S. Rubber has used all five types and knows which one to select for the performance required.

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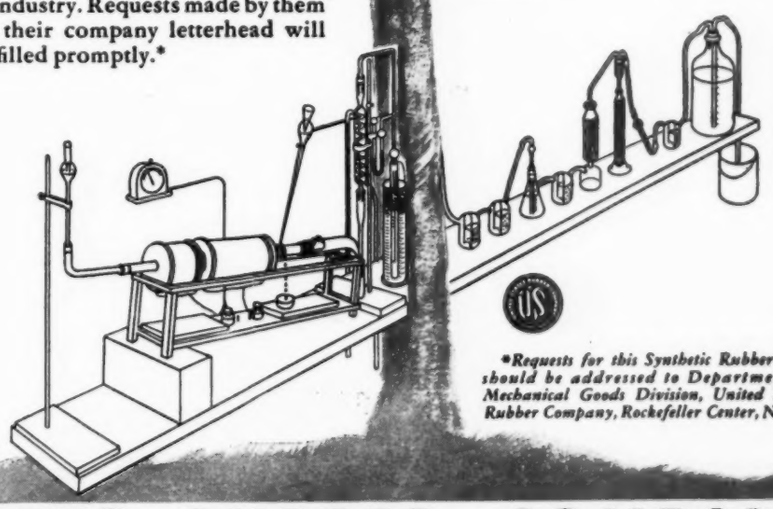

**Requests for this Synthetic Rubber Book should be addressed to Department 19 Mechanical Goods Division, United States Rubber Company, Rockefeller Center, N.Y.C.*

UNITED STATES RUBBER COMPANY

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Fig. 4. Repair at a pipe joint in 10-in. oil line. Half-sole is welded over coupling as shown. Note section on right has been half-soled all around. Section on left has the lower part half-soled

ed hammer, reveals the pits and corroded areas. The inspectors employ special gauges for determining the depth of the corroded areas. If the pit is deeper than 10 to 15 percent of the wall thickness, it is repaired. Pit holes are chalked by the inspector.

If the chalked pit holes are not too numerous they are filled-in with weld metal by the welder. Care should be taken in welding pit holes not to burn through the pipe or maintain the arc for an undue length of time at any one spot. As the welding arc works fast and the heat is soon dissipated, however, there is little possibility of danger with this welding process. Pit holes filled in this manner vary in size up to areas of almost a square foot. Often more than one layer of weld metal is required to bring up the corroded spots flush with the pipe. One-fourth-inch mild steel shielded arc electrodes (or $\frac{3}{16}$-in. size for overhead welds) are generally used.

Corrosion of the pipe is usually three to four times as bad on the bottom of the pipe as on the top half. Because of this, most companies turn the pipe over (by unscrewing 180 deg. in coupling) so that the old top will be the bottom of the line when it is relaid. This is done when the old screwed couplings are to be welded to the pipe and especially in cases where the condition of the pipe is bad and there are not too many bends.

When corrosion is more extensive it is usually advisable to weld on sections of new steel either half way or all the way around the worn pipe. Following is the procedure used by one large oil company: Half-soles are cut in any desired length from new pipe of the same diameter size as the pipe being repaired, or are rolled to proper shape from new steel plate about $\frac{3}{8}$-in. thick. These are then clamped (see Fig. 3) and tack-welded in place. The clamp is then removed and the half-sole is lap-welded along both longitudinal and girth seams, providing a jacket that is permanently tight.

If there are leaks in the old pipe through which oil is escaping, a cardboard gasket may be placed over the hole and the half-sole plate is then fitted over the gasket to shut off the oil until welding is completed.

Two beads are recommended for these welds. The first bead is run with $\frac{5}{32}$-in. mild steel shielded arc electrodes. The second bead is made with $\frac{3}{16}$-in. or $\frac{1}{4}$-in. electrodes. A combination of these two beads gives a permanently leak-proof joint. The girth welds (vertical and overhead) are usually made with $\frac{3}{16}$-in. electrode.

If pipe at collars or couplings is not in very bad condition, showing only minor leakage, both sides of the collar can be lap-welded to the pipe. These girth welds are usually made with $\frac{3}{16}$-in. electrode.

When leakage conditions at collars are bad, the collar is usually jacketed with steel half-soles, cut from new pipe.

After the line is reconditioned by arc-welding, a protective coating of paint is usually added, and in some instances the line is wrapped for further protection. It is then re-laid in the ditch and covered.

Many natural gas pipe lines are also repaired while in operation with full pressure on. The procedure used is similar to that used for oil lines, as described.

Welding under pressure is considered safer than welding a line full of gas without pressure. Under the latter condition, explosive mixtures of gas and air may be encountered.

☆ ☆ ☆

TABLE 3

Work completed by one leading welding contractor during 1942

Owner	Size pipe, in.	Miles	Cargo	Construction	Location
Panhandle Eastern Pipe Line Co.	8	51	Natural gas	Stove-pipe and firing-line	Galesburg to Peoria, Ill.
Phillips Petroleum Company	8	143	Gasoline	Stove-pipe	Borger, Texas, to E. St. Louis.
Panhandle Eastern Pipe Line Co.	12–16–18–20	154	Natural gas	Firing-line	State of Michigan.
Illinois Pipe Line Co.	8	8	Oil	Firing-line	Lancaster to Parkersburg, Ill.
Phillips Petroleum Company	8	67	Gasoline	Stove-pipe	Paola to Kansas City, Kansas.
Panhandle Eastern Pipe Line Co.	12	4	Natural gas	Firing-line	Louisiana, Mo. to Montezuma, Ill.
Phillips Petroleum Company	6–8–12	291	Gasoline	Stove-pipe	Goldsmith, Texas to Hobbs, N. M. to Borger, Texas.
Independent Industrial Gas Co.	6	5	Natural gas	Stove-pipe	Near Coffeyville, Kansas.
War Emergency Pipelines, Inc.	24	77	Oil	Firing-line	State of Akransas.
Illinois Pipe Line Co.	8	150	Oil	Firing-line	Lima to Sparta, Ohio.
Dow Chemical Co.	3–4–6–8–10–12	18	Water	Firing-line	State of Michigan.
Phillips Petroleum Company	8	2	Gasoline	Firing-line	River Crossing near St. Louis.
Sunflower Ordnance Plant	16	11	Water	Stove-pipe	Eudora, Kansas.
Ohio Emergency Pipe Line, Inc.	8	40	Oil	Stove-pipe	Dayton to Greenwich, Ohio.

All of above pipe lines are solid welded using plain end pipe.

View of exterior piping. Note sump eductor control valves adjacent to wall of building. Small vessel at right is used to inject inhibitor

New Type Automatic Pump Station

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☆ Simplified control apparatus fabricated from non-critical materials

by S. S. Smith

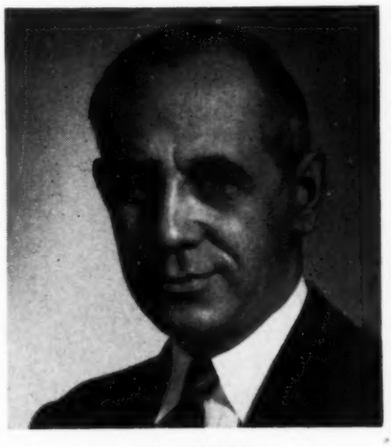
Manager, Products Pipe Line Department, Shell Oil Company, Inc.

THE product pipe line of the Shell Oil Company, Inc., from Wood River, Illinois, to Lima, Ohio, is an 8-in. line. It is equipped with electric-motor-driven centrifugal pumps having a capacity up to 27,000 bbl. per day of gasoline.

Each station is automatically controlled and built around a 500-hp. explosion-proof motor running 3560 r.p.m. and driving a 6-stage centrifugal unit capable of an output pressure up to 850 lb. at the rated throughput of 1140 bbl. an hour. The pump efficiency is 80 to 82 percent and the stations have been in operation for about five years.

These stations are automatically controlled by conventional means using Mercoid switches for start and stop relay actuation and controllers for air actuation of the control valves at the pump. The layout in scheme is shown in Fig. 1 and Appendix A describes the operation of the station.

Project Three of the Pipe Line Committee of P. A. W. (nee O. P. A.) required among other items of construction that the company augment the capacity of its line between Zionsville (near Indianapolis) and Lima by the addition of a new station at or near Muncie, Indiana. Because there already was a terminal at Muncie it was chosen as the new station site, although it is somewhat upstream from the hydraulic center of the line.



S. S. SMITH

was born in Parkersburg, West Virginia, and graduated from Marietta College—In 1915 he went to Burning Springs, West Virginia, where, with his father, he constructed and operated one of the first compressed-air plants for recovering oil from stripper leases—After serving in the First World War he went to Oklahoma in 1919 as representative of the Miller Engine Company—Later he designed, constructed, and operated natural gasoline plants for the Oklahoma Gasoline Company—In 1924 he became associated with the Roxana Oil Company, now Shell Oil Company, Inc., and was manager of the natural gasoline division in Tulsa until 1935—Transferred to the company's St. Louis office, he worked for three years in the refinery division—In 1938 he was placed in charge of products lines—Now makes his headquarters in New York City.

As is well known, materials were already scarce and time was important because of the pressing need to move fuel oil and gasoline east as quickly as possible. The company already had the necessary pumps and motors and most of the required switchboard control apparatus, but did not have and was unable to obtain satisfactory delivery on air controls for the new station. As a result, it was decided to build a station of simplified control using apparatus designed by the company that could be fabricated from non-critical materials in shops not already heavily loaded on orders for the Army or Navy. Designs had already been roughed out and it was only necessary to find a manufacturer who was willing to undertake a special job and who was able to carry through from rough plans to finished controller of workmanlike design.

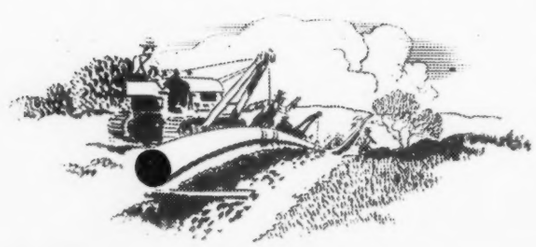
Station Flow

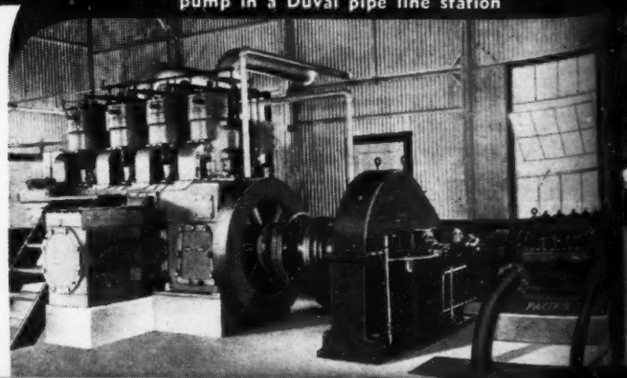
The design that the company desired to control the major pressure and flow items is shown in Fig. 2. In this illustration is shown the fluid flow, starting from bottom left, through the pipe line, bypass check valve and station suction lines, main suction valve, pressure reducing control, pump and motor, next the main valve (called around the company engineering office, but with varying degrees of affection, the "Rube

(*Continued on Page 172*)

Four 6-cyl., 600 H. P. Clark "Angles", Canadian River Gas Co. pipe line station

Clark 400 H. P. "Angle" driving oil pump in a Duval pipe line station





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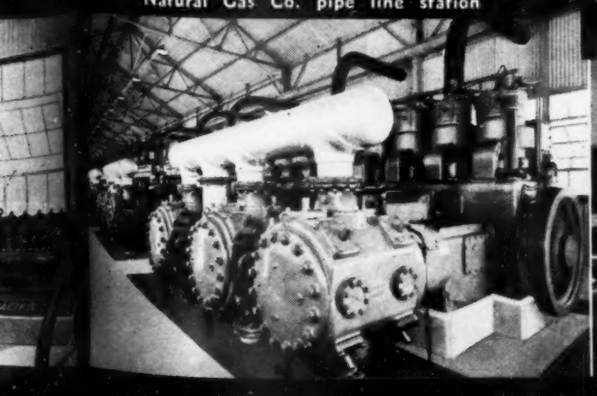
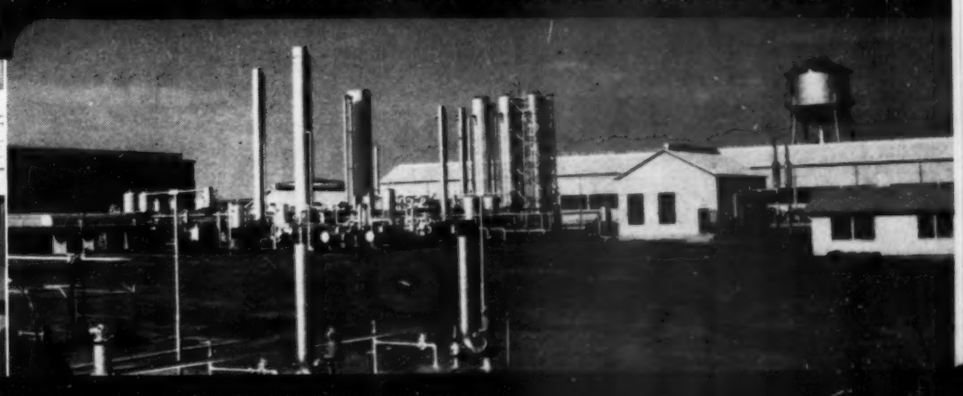
600 H. P. "Angles" in an El Paso Natural Gas Co. pipe line station



Exterior View, El Paso Natural Gas Co. pipe line station



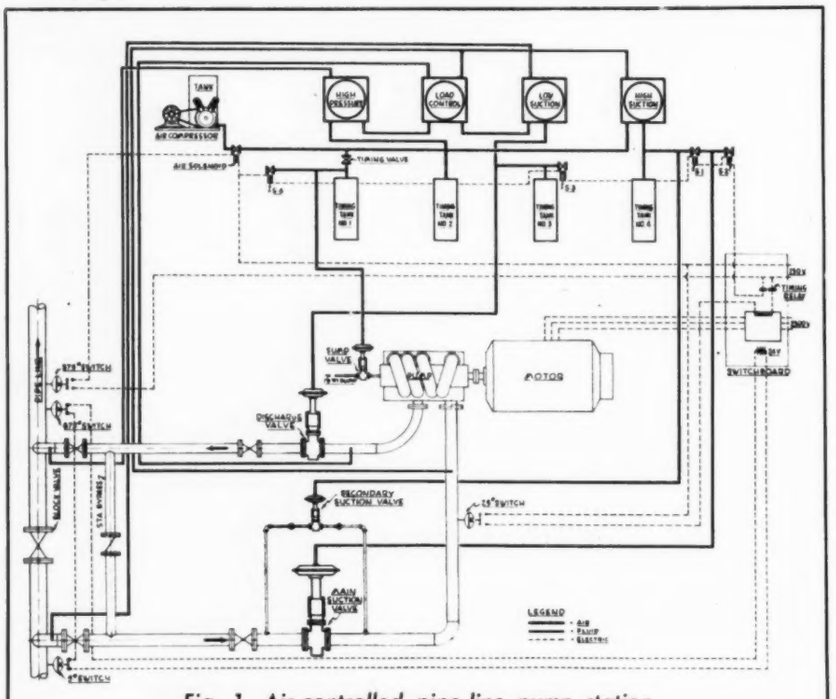


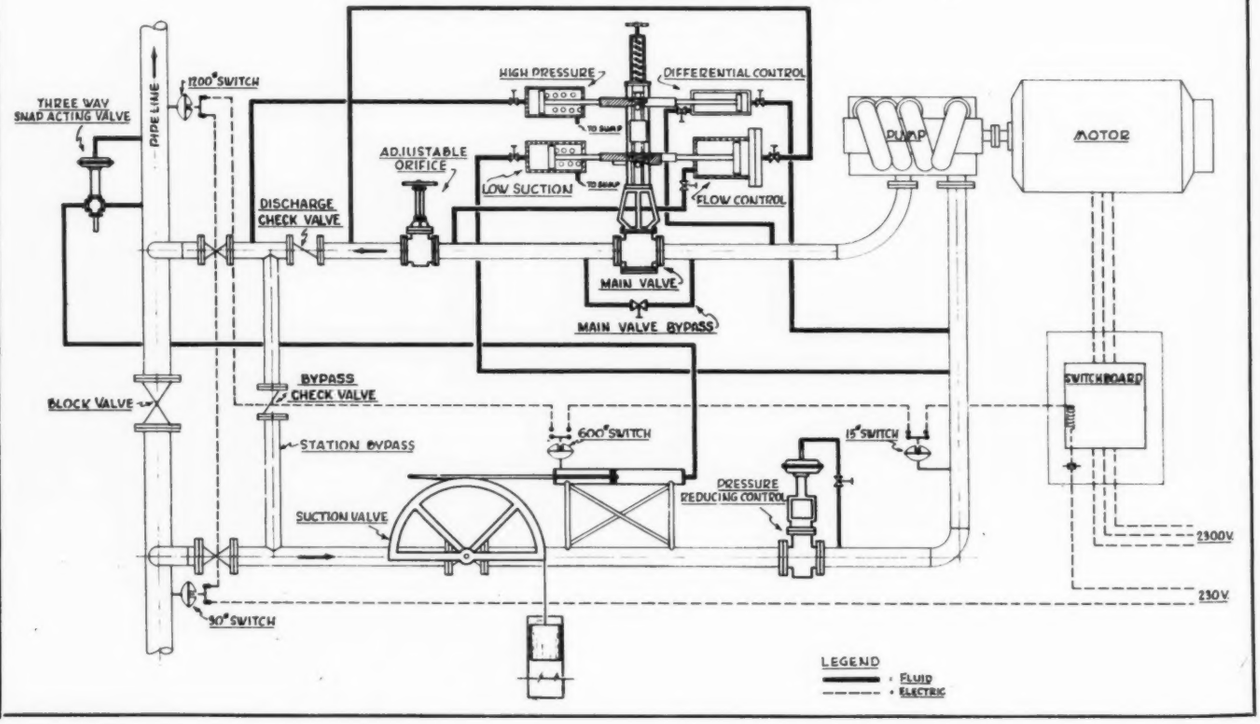
Fig. 1. Air-controlled pipe-line pump station

(*Continued from Page 169*)

Goldberg") through the adjustable orifice, the final discharge check valve, and again the pipe line. As this flow sheet is somewhat different from the usual pipe-line station flow sheet, a description is in order.

Operation of the station is dependent upon the line pressure passing the station. If this pressure is lower than 625 lb., the station remains inoperative with the suction valve closed and with the check valve on the discharge line holding against the pipe-line pressure. If the station is down for any length of time, the hand-operated main valves are closed, otherwise they remain open and station operation is fully automatic. When pressure rises in main line to 625 lb. or above, the three-way snap-acting valve opens and permits passage of 625-lb. fluid from the line to the cylinder and piston mechanism of the suction valve. This valve opens slowly at a rate controlled by small orifice in the pressure line to the cylinder, and as the valve slowly opens fluid is admitted to the pump, building pressure through the entire system up to the check valve in the main discharge line. This brings the pump pressure on both suction and discharge side up to 625 lb., the pressure acting on both sides of the piston of the differential control. As this is an unbalanced piston by the area of the piston rod (¾-in. diameter), the piston moves outward. This movement of the piston brings a cam into contact with a roller assembly on the guided main valve stem, closing the main valve. It should be noted that any one of the cylinders on the main valve can close the valve, all must be in proper position for the valve to open. This flow purges the pump, condensing any occluded vapors and filling the entire pump body. As the piston of the suction valve completes its travel, the piston uncovers a port in the cylinder, which admits fluid to a 600-lb. switch, closing a relay circuit to the switchboard. This relay circuit activates the switchboard causing the timing relays to run through their automatic timed sequence and brings the motor up to full speed in about 20 to 25 seconds. As the motor and pump come up to speed, fluid circulates through pump and main valve bypass through the discharge check valve and pump is maintained cool and fluid lubri-

Fig. 2. Direct-controlled pipe-line pump station



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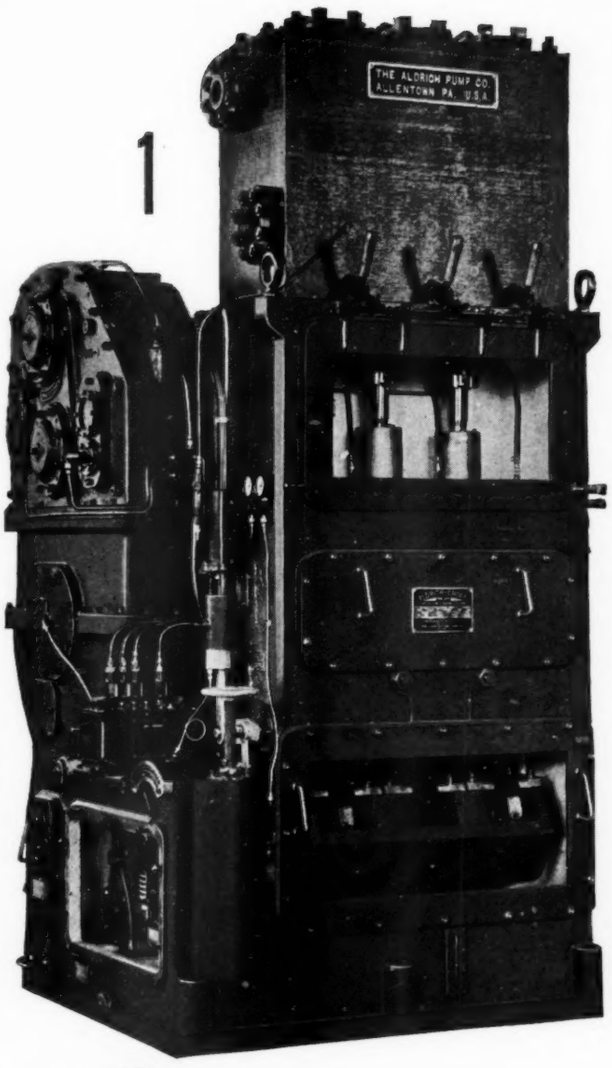

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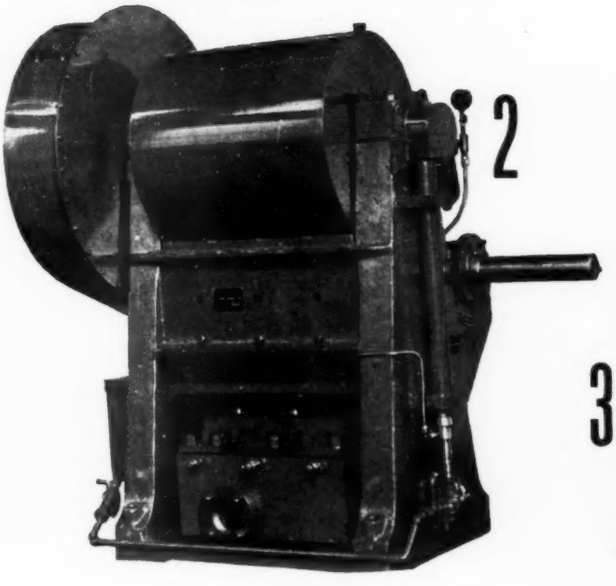

2

3

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THE ALDRICH PUMP CO. ALLENTOWN, PENNA.

cated. The differential pressure created by the pump affects the differential control, this time with the high pressure on the inner or valve end of the cylinder, and the unbalance of pressure this time in reverse direction from the previous action pushes the piston back in the cylinder and the main valve opens. The rate of movement here is regulated by a needle valve in one of the pressure lines to the cylinder; in the previous action there was no such restraint because of a check valve bypassing the needle valves. These items are not shown in Fig. 2 for the sake of simplicity but are necessary to provide proper timing, which will permit the main valve to open quite slowly, providing sufficient time for the pressure-reducing control to open and control suction pressure. Also, as flow is established through the pump by opening of the main valve, the load through the pump will become very heavy, as there is equal suction and discharge pressures on the line until the incoming line pressure is pulled down to normal running point and until the discharge line is built up to normal running point. To prevent overloading, a second cylinder on the main valve, known as the flow control, is balanced across the pressure drop through the adjustable orifice. The piston and piston rod diameters are calculated so that 5-lb. differential pressure across the adjustable orifice is required to balance the piston. Thus, when orifice pressure drop exceeds 5 lb., the piston away from the main valve and the connected cam depresses the valve, throttling the throughput of the motor. The piston is self-positioning, there are no springs, and whenever pressures are unbalanced, it is free to move to the full extent of its travel. It only operates at the time of starts or when heavy fuels are passing through the pump. It approximately compensates for the gravity of the fluid passing the pump because the pressure drop through the orifice is a function of both gravity and viscosity. The accuracy of this approximation proves to be sufficiently good to maintain satisfactory load conditions on the motor throughout the range from light gasolines to medium distillates without changing adjustments of the variable orifice.

Station Controls

When flow has been established through the pump and the load control has taken hold of the throughput to prevent overloading of the motor, the station is "on the line" and incoming pressure will be pulled down and the discharge pressure built up as rapidly as the horsepower characteristics of the motor and flow characteristics will permit. In the Muncie station this is quite rapid on gasoline, a matter of about three minutes, and on fuel oil perhaps eight to ten minutes. During this "pull down" period, the suction pressure to pump is held at 300 lb. maximum by the pressure-reducing control, the purpose of this being twofold, to protect the pump packing against excessive pressure, and to preclude dangerous pump discharge pressures, which might reach 1400 to 1600 lb. except for this protection.

As the pull down period is completed, the pump either balances to meet the line throughput or must be throttled to prevent discharge pressures going too high or suction pressures going too low. The Muncie station, as mentioned, is upstream from hydraulic center of its section of the line, so that when flow is at maximum, its normal condition, the station operates wide open with a suction pressure of 200 to 250 lb. and a discharge pressure of about 1050 to 1100 lb. If, however, product is taken from the line at an upstream station so that the line throughput is reduced, but not sufficiently to take the station off the line, then the suction and discharge pressure both drop and if not prevented, the suction pressure could go low enough to cavitate the pump thus destroying wearing rings and perhaps sticking the pump. In this event, however, the spring-balanced piston of the low suction control retracts into the cylinder when suction pressure ap-

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proaches 30 to 40 lb. and again the main valve is partially closed, thus throttling the pump.

If, instead of a low flow condition, the situation is reversed and more fluid comes in than the station can handle, then the discharge and suction pressures will rise. This situation can occur if gasoline is upstream of the station and fuel oil downstream, in which event, both pump suction and line discharge pressures are protected against excessive rise by the operation of the pressure reducing control on the suction side and the high pressure on the discharge side of the pump.

Other Safeguards

The foregoing are the normal or throttling controls of the station. In the event of unusual line or station troubles, there are a number of additional safeguards. If the incoming line fails due to break or shutdown of upstream stations, this station will first throttle by operation of low suction at the main valve and next because fluid continues through main valve bypass in small amount and the suction pressure will fall low enough to operate the 15-lb. switch, thus shutting down and protecting the pump against dry operation.

If through accident or otherwise a main-line valve is closed downstream from this station, the discharge pressure will rise, operating the high pressure and closing the main valve. Again, however, fluid will continue in small amount through main valve bypass and the discharge pressure thus created will operate the 1200-lb. switch and shut down the pump. In the event of this sort of shutdown, the pump is not protected against excessive packing pressures because the suction valve remains open. Under these conditions it would be expected that the pump would require repacking. As this occurs only in emergency, and as once operated the 1200-lb. switch must be reset by hand, this feature has not been considered a serious drawback. In the earlier instance cited, this criticism would not apply, for immediately the pump stopped because of low suction, the discharge pressure also falling would open the three-way snap-acting valve and would release fluid from the cylinder of the suction valve, which, being counterweighted, immediately closes. The released fluid from the three-way snap-acting valve goes to sump.

In addition to the protection afforded against line failures internal to the station, there is provided ample protection to the motor and pump by seven Mercoid switches, temperature-actuated by any high temperature at pump stuffing boxes, pump case, pump bearings, or motor bearings. They are connected in series with the pressure switches (but not shown in Fig. 2) and each requires hand reset after actuation. Also not shown in Fig. 2 is an alarm system that notifies adjacent terminal operators of any failure or stoppage. Also not shown is an alarm on the sump that notifies of excessive leaks such as would be caused by packing failure.

Automatic Sump Mechanism

The automatic sump mechanism is shown in Fig. 3. As it is intended to operate on a fully automatic and only partially attended basis, provision is required for automatically draining the sump. Usual practice is to pump it by an automatic float controlled pump, but this method has two drawbacks; it increases the demand figure for power out of proportion to the energy actually used in occasional operation, and the sump may pump automatically just after a batch of product has been succeeded by another product easily contaminated. This last defect is serious and where float pumps are used, it is customary to see batch heads through the station by having attendants called out by the dispatching office manually to drain the sumps, etc. It was desirable to

(*Continued on Page 178*)

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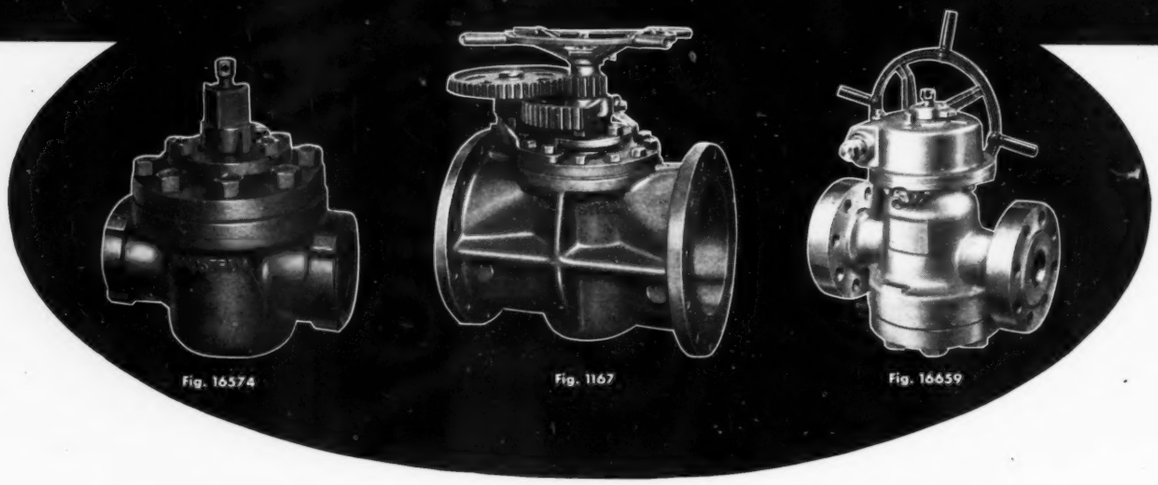

Fig. 16574 Fig. 1167 Fig. 16659

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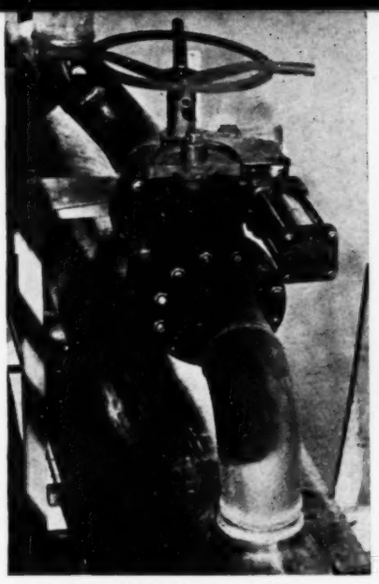
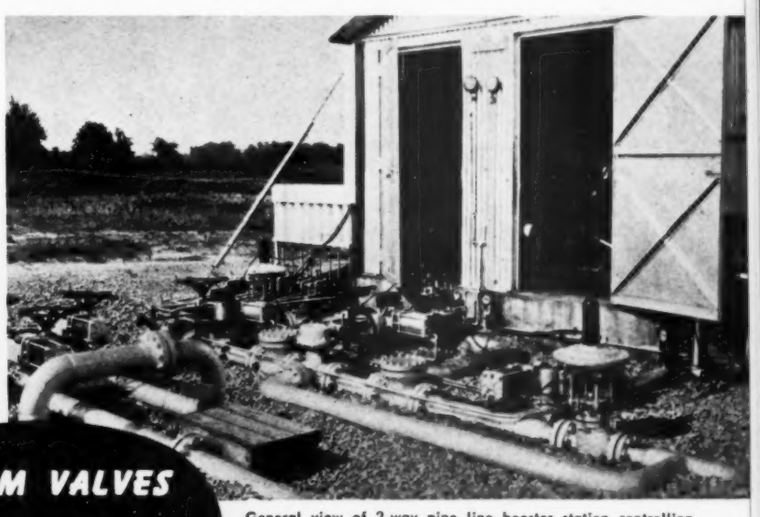
Series of Nordstrom Automatic Pipe Line Valves installed at a river crossing.



Nordstrom 6" Cylinder Operated Valve on Mississippi River bridge installation. Used for blow-off service on pipe line.

Nordstrom Valves on natural gasoline pipe lines in a Gulf Coast refinery.

Series of Nordstrom Motor Operated Valves on manifold on property of a leading southern pipe line company.



General view of 2-way pipe line booster station controlling flow of gasoline automatically with use of Nordstrom Valves.

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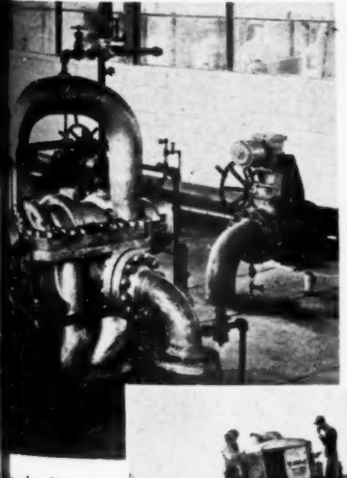
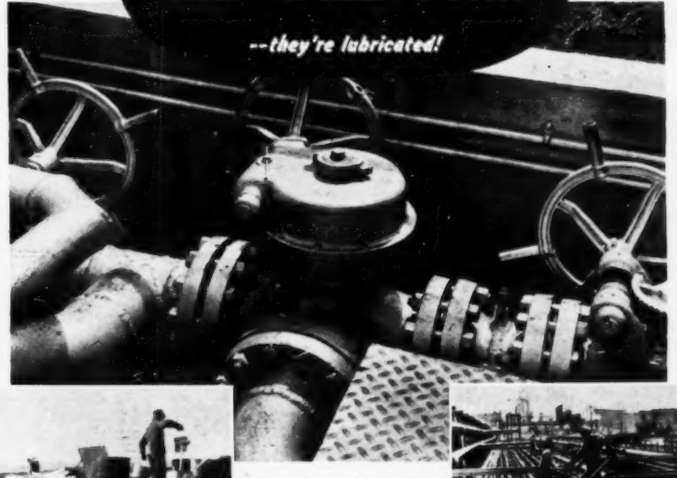
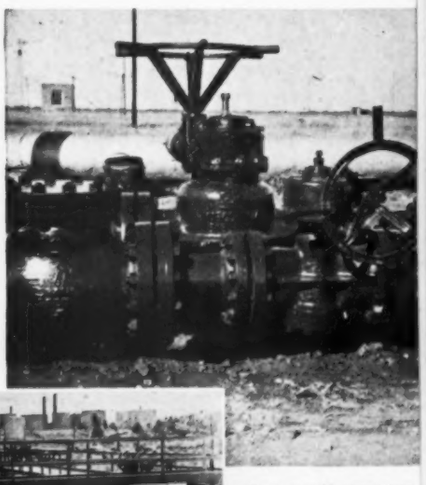






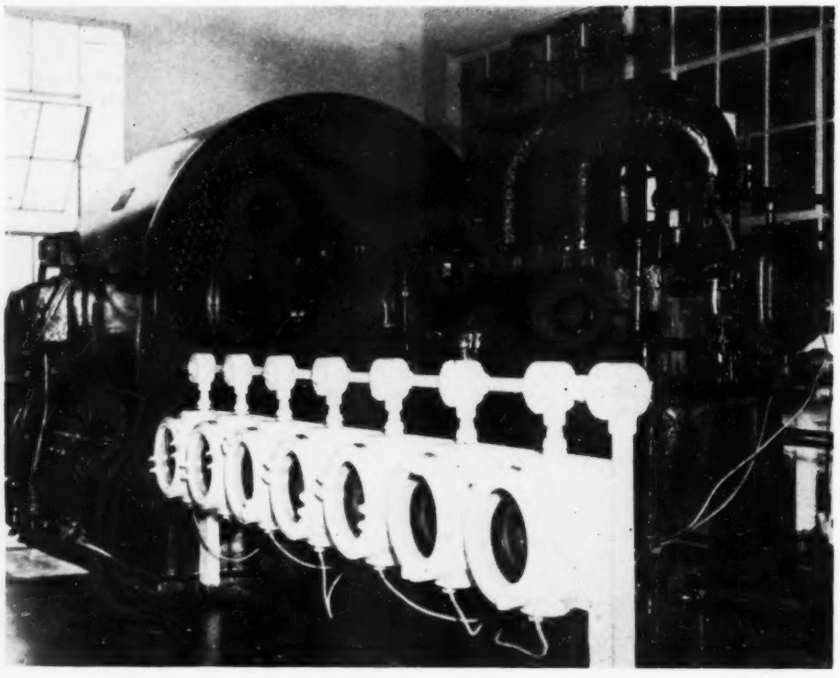
pipe line sta- the Nordstrom are operated by c motors, or can nually operated.

(At right)
ing Nordstrom Operated Valves s transmission for city service.

Nordstrom 4" 3-way Hypreseal Multiport Valve delivering gasoline in a Michigan bulk terminal at 900-lb. pressure.

Close-up of scraper trap piping of a Mid-Continent pipe line, controlled with 8" Nordstrom Valves.

(At left)
Battery of pipe lines leading to a large refinery. The man is operating a Nordstrom.



Pumping unit comprising 500-hp. totally enclosed motor and 6-stage centrifugal pump. Motor bearing and pump bearing, gland and case temperature mercury switches in foreground

(*Continued from Page 175*)

improve this practice in the station, so the apparatus of Fig. 3 was designed. The sump tank is built with a slope to a submerged well, which neatly encloses the eductor and its float. The holdup of material in drain lines and this sump well is only about 5 gal.; therefore, the contaminating effect on an hourly stream of 1100 bbl. passing the station is negligible. The eductor proper requires about a 3 to 1 pressure ratio to operate; therefore, the two eductor control valves are set to require over 900 lb. pump discharge pressure and less than 300 lb. pump suction before they both open and admit high-pressure fluid to the eductor itself. When station operation starts, some fluid is accumulated in the sump, but as soon as flow and normal pressures are established both valves open and the eductor goes to work. When fluid level falls in the sump as educted, the float control shuts off the inlet from the sump and thereafter the level is maintained constant at that point. This sump operation requires no special handling at the passage of a tender or batch head through the station and, in fact, operators are not even notified of the passage of tender heads except in the case of very special products such as 100-octane gasoline for which special procedure is used.

The station has been operating about four months and is considered a complete success without troubles or failures apparent. This overlooks minor tune-up adjustments that had to be made when equipment was first started, but such minor items were expected and not considered serious.

Acknowledgment for assistance in design is made to Hanlon-Waters, Inc., of Tulsa, Oklahoma, for the main control valve, the pressure-reducing control, and the float mechanism for the eductor, to Schutte Koerting for the eductor, and to Westinghouse and Mercoid companies for the motor control and pressure switches.

Patents covering this type installation have been taken by Shell Development Company.

Appendix "A"

Conventional stations have been built almost as shown in Fig. 1. The operations is as follows.

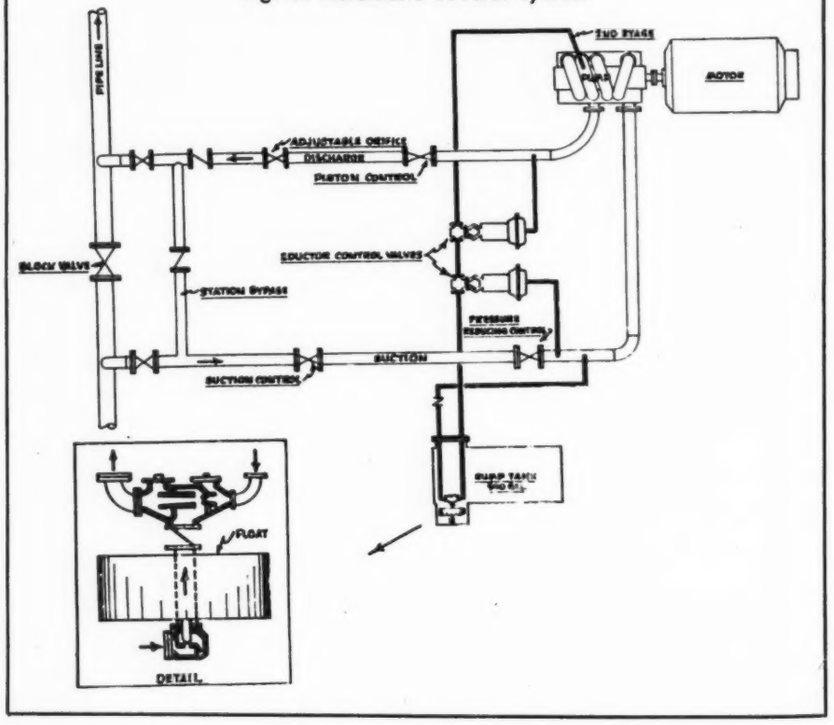
The so-called 375-lb. switch is the main control of the station. Normally the station operates if this switch is above set point, and shuts down if line pressure is lower than set point. This switch incorporates a combination of flow control, making use of pressure drop across the line as an index of flow, and low-pressure drop-out switch in case of a line break downstream but close to the station.

The sequence in starting is as follows: 375-lb. switch closes, making circuit to main air solenoid, which opens air to air control instruments. With pump inoperative as it is at this stage of the sequence, the air does not get to the discharge valve. The high-pressure control, with low pressure on the pump, is open to air; the load control, with no differential across the pump, is closed to air; and the low suction controller, with low suction on the pump, is open. The high suction control receives and passes air, the pump suction pressure at this stage being negligible.

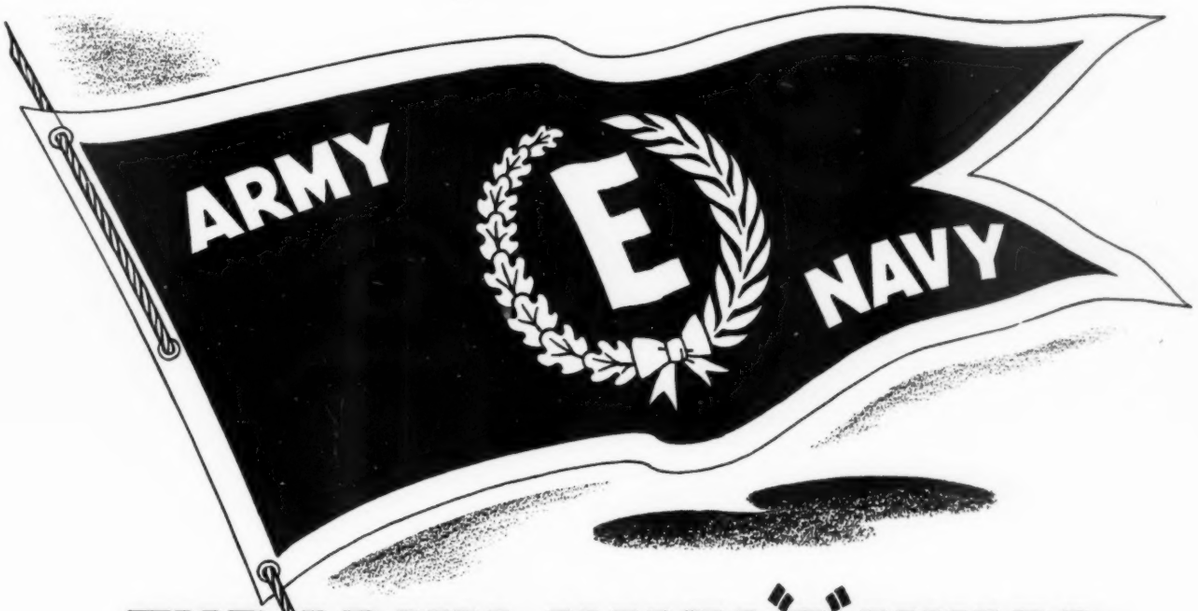
Air passes the high suction control-

(*Continued on Page 182*)

Fig. 3. Automatic eductor system



and Now . . . . .



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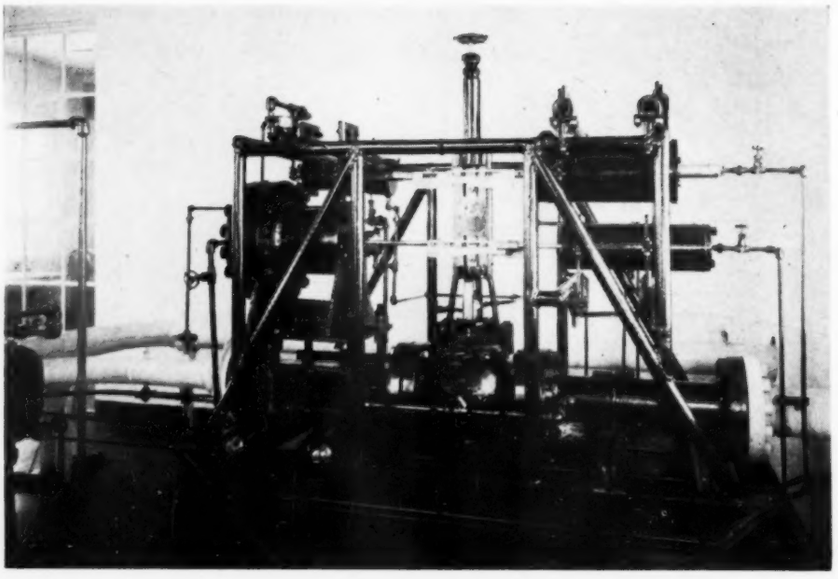


Main valve showing arrangement of differential and flow cylinders (left) and discharge and suction cylinders (right). Bypass in immediate foreground

(*Continued from Page 178*)

ler, but with S_1 closed, the air can only reach the secondary suction valve, which opens permitting fluid to enter and build pressure in the pump. This pressure causes the 25-lb. switch to make contact, closing the starting circuit in the motor and also starting the timing relay in the main electrical circuit. During the action of the timing relay, the motor operates under reduced voltage, gradually building up to speed with a small flow of fluid passing through the secondary suction valve and through the pump to sump through the open sump valve. At the end of the timing relay sequence, contacts close and make the electrical circuit through all S switches, opening S_1 and closing S_2, S_3 and S_4. These operations admit air to main suction valve through S_4 and by closing S_3 stop the air spill from discharge valve and permit air pressure, which now passes the load controller, to build on this valve through timing tanks 2 and 3 whose combined volume assures slow opening of discharge valve. At the same time, time tank 1 delays, but permits closing the sump valve, so that when properly adjusted the sump valve is closed when the discharge valve opens.

Before the discharge valve is opened, the timing relay has closed S_2 and opened S_1, which kicks the large volume of air in timing tank 4 into the comparatively large diaphragm of the main suction valve, and holds it open for an appreciable time. This is one of the timing techniques of this starting sequence, the secondary suction valve being spring-adjusted to require high air pressure, and the main suction being adjusted to require low air pressure. These factors, in combination with the large volume timing tank 4, assure good suction pressure on pump during the discharge valve's opening and prevent the 25-lb. switch kicking the pump off as the discharge valve opens.

Emergency controls include temperature switches on the pump glands, pump bearings, motor bearings, and pump case temperatures. A rise in any one of the temperatures shuts down the unit at once, as does low pressure at the 375-lb. switch, high pressure at the 875-lb. switch and low pressure at the 5-lb. switch.

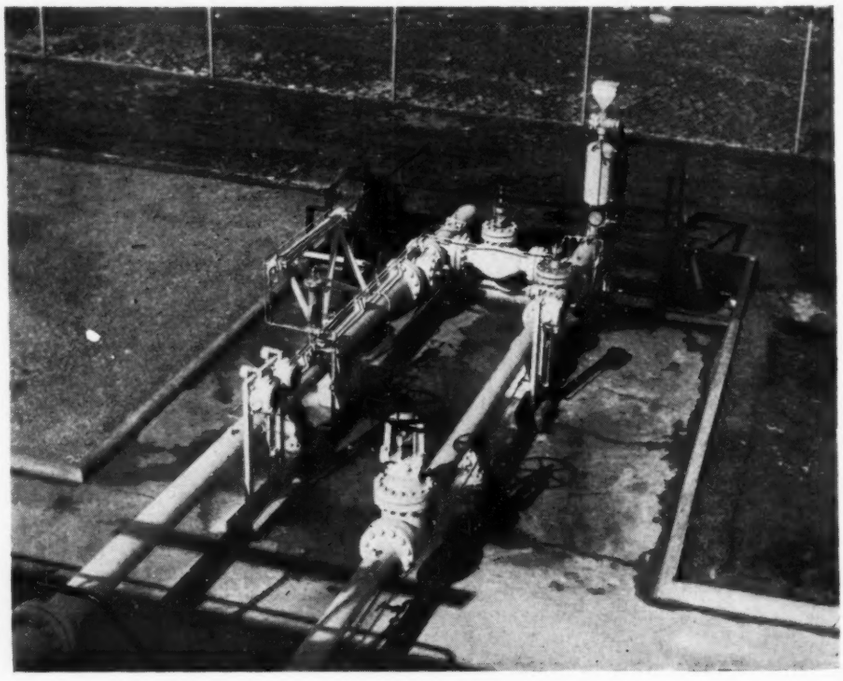
The shut-down sequence is quick and simple. When any of the emergency switches kick out, the main motor circuit opens stopping the current flow in the motor. S_2, S_3 and S_4 open, spilling air on all diaphragms and closing main valves, also opening sump valve. As the pump coasts to a stop, the suction control opens once or twice on the air contained in time tank 2, and the liquid thus admitted to pump cools the wearing rings and assists the stop.

When station is not operating, fluid passes in the main line through the station bypass and stop lift check.

Air-controlled stations are fairly complicated systems requiring careful training of operators in order to assure their ability to make occasional adjustment as needed. Even so, they have given good operation without failures in several of the company's East Line stations since 1938. Similar stations have shown fine operating performances for the Susquehanna and Plantation systems.

—— ☆ ☆ ☆ ——

Plan view of exterior piping showing suction valve and, immediately in front of it, the three-way snap acting valve. Adjustable orifice in lower center of picture



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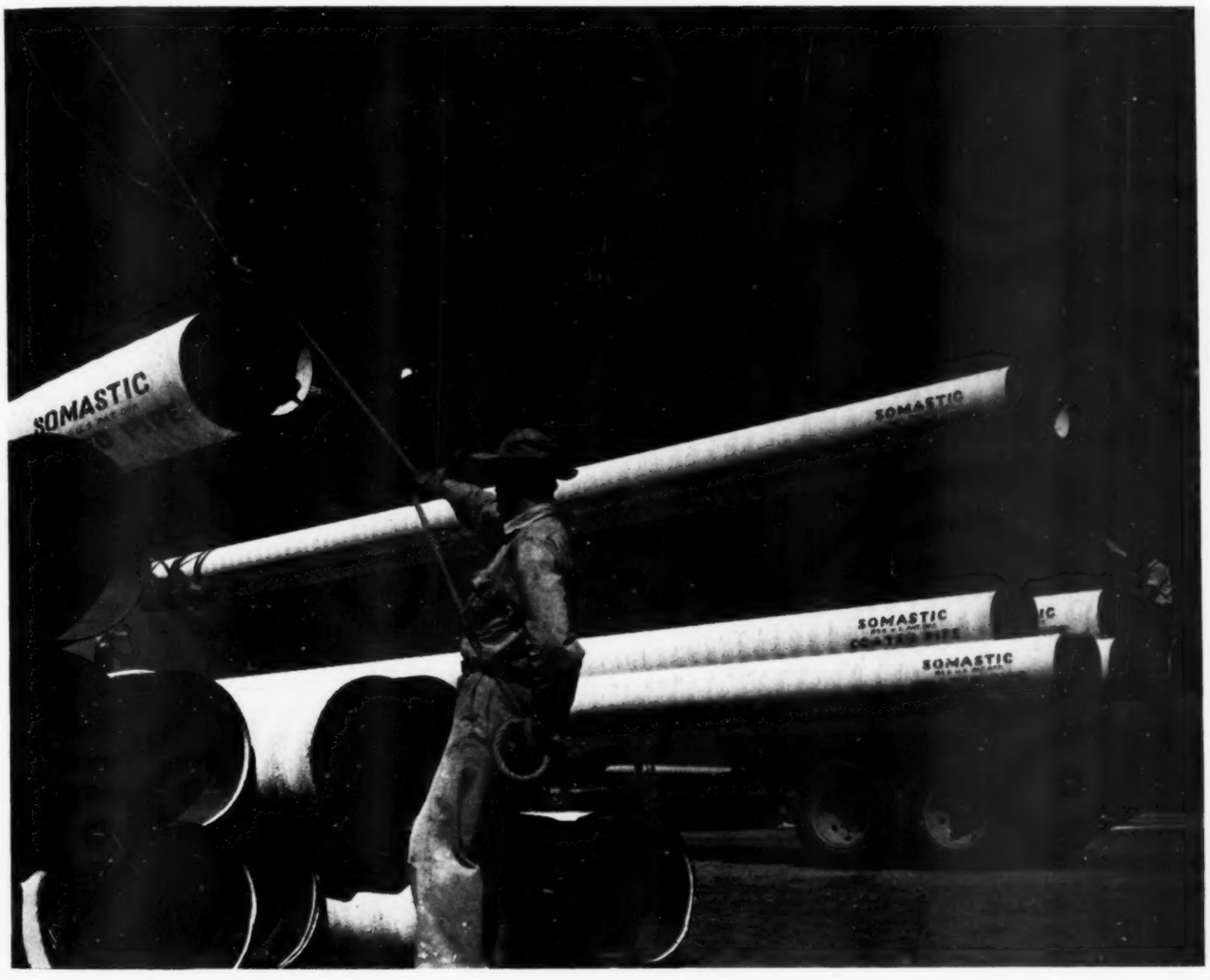

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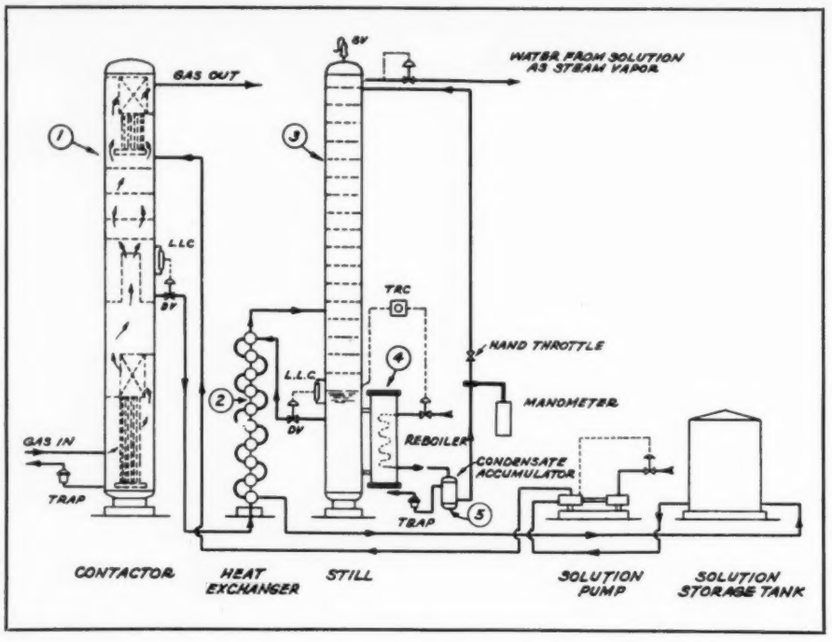


Fig. 1. Hygroscopic liquid system

PETROLEUM ENGINEER Exclusive Feature

Natural Gas Pipe Line Dehydration

☆ Recent developments discussed, and operating experiences of several plants given

PART 1

by

Henry N. Wade

President, Parkhill-Wade

IN A previous article* the writer presented a short summary of the development of plants for natural gas pipe line dehydration up to that time, together with a fairly complete bibliography. In that article the principal types of dehydration systems were briefly described.[8]

The purpose of this article is to bring the information on the development of natural gas pipe line dehydration up to date, and to present information that has accumulated from the writer's experience during the intervening time.

Types of Dehydration Plants

The types of plants now in common use are the same as those described in the previous article. This material is reviewed briefly.

Dehydration plants are divided into two general classifications; those using a continuous circulation of a hygroscopic liquid for removing water from the gas, and those using solid moisture adsorbent materials, usually in granular form.

Hygroscopic Liquid Systems[1]

A typical flow sheet for a dehydration plant using a hygroscopic liquid is presented in Fig. 1. The gas to be treated is passed upward through conventional bubble-cap type plates in the absorber (1) where it makes contact counterflow with the stream of hygroscopic liquid. Usually some sort of scrubber is installed in the base of the contactor to protect the system against dirt and slugs of liquid coming in with the wet gas. Highly efficient scrubbing means must also be provided at the outlet from the contactor plates to thoroughly remove entrained liquid, as the treating liquids are usually expensive and are not desirable in the transmission lines. Both the inlet and outlet gas scrubbers can be installed in the same shell with the contacting bubble plates if desired, with considerable economy in vessel cost and piping.

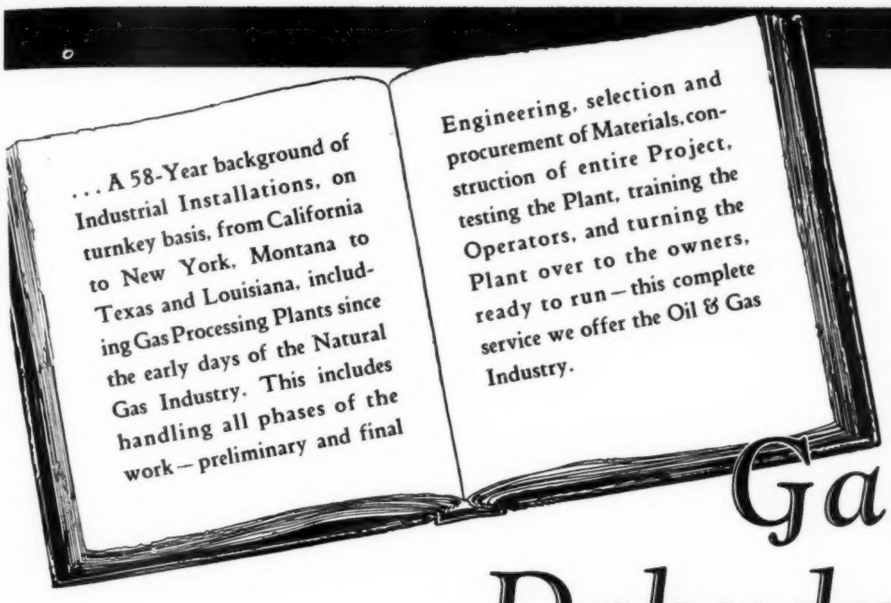
The partly diluted solution leaves the base of the contactor through a level control and passes through a heat exchanger (2) to the still (3) where it flows downward over bubble plates into the base. The temperature in the base is kept at the desired point by means of the reboiler (4), which ordinarily uses steam as a heating medium.

The still is refluxed by a small amount of distilled water admitted to the top tray to prevent the escape of vapors of the dehydrating fluid. This reflux water may be obtained from a condenser on

HENRY N. WADE

received the degree of mechanical engineer from Cornell University in 1914—Undergraduate work was obtained at the University of Southern California in 1909-10—Served as development engineer for Cutler-Hammer Manufacturing Company, 1914-21—Was with Keystone Iron Works, Los Angeles, 1921-23—Served as manager, natural gasoline plant, U. S. Refining Company, Los Angeles, 1923-26—Acted as sales representative and sales engineer, respectively, for Lincoln Electric Company and J. A. Campbell Company, 1926-32—Has held the position of president of Parkhill-Wade, Los Angeles, since March 15, 1932.

*Gas, May, 1940.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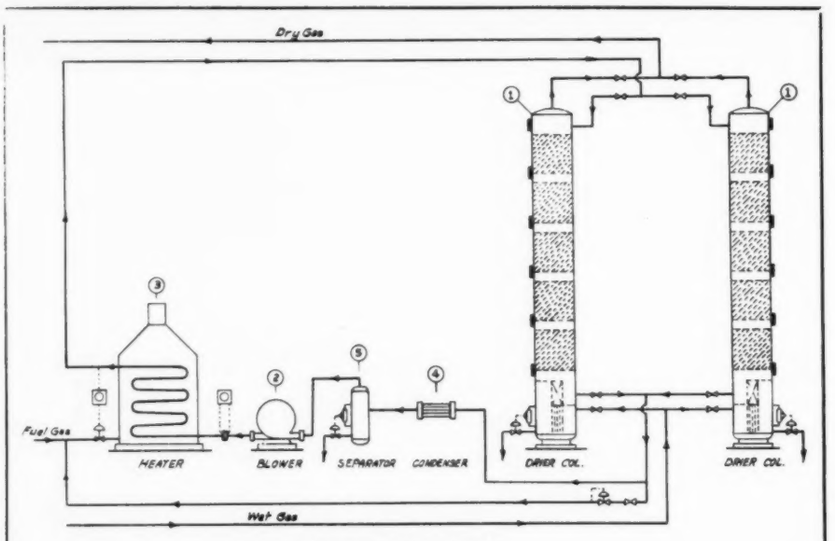

Fig. 2. Solid adsorbent

the vapor outlet, from the condensed steam leaving the reboiler (5) as indicated on the flow sheet, or with small stills by condensation within the upper part of the still itself through radiation.

In special cases the heat in the base of the still is provided by using some heating medium other than steam, such as "Dowtherm," for supplying the heat to the reboiler. In other cases it may prove economical to use a direct-fired heater, preferably with a pump-forced circulation.

The temperature in the base of the still can be maintained constant by a temperature controller regulating the supply of steam or other heating medium to the reboiler, or controlling the fire in a direct-fired heater. Where the boiler used for operating the still is devoted to this one purpose only the reboiler can be mounted high enough to permit gravity return of the condensate to the steam or Dowtherm boiler, and the still base temperature controller then operates on the fuel gas to the boiler burner.

The concentrated hot solution from the base of the still is conducted back through the heat exchanger to the suction of the solution pump, which returns the cooled and dried solution to the contactor, closing the cycle. Cooling may be provided at the outlet of the dried solution from the exchangers if it is important to gain the last possible degree of dewpoint depression. Ordinarily such cooling is not necessary, as the heat capacity of the solution stream is much smaller than that of the gas stream, so that solution temperatures as high as 120 to 130°F. will not raise the effective contact temperature and resulting dewpoint more than one or two degrees.

The solution pump is sometimes connected at a point part way through the heat exchanger in order to minimize the still pressure required to deliver solution to the pump suction.

Systems of this kind can be used with several different hygroscopic liquids. The principal liquids being used for this purpose are strong solutions of diethylene glycol and solutions of calcium chloride.

During recent years the trend has been away from calcium chloride because of the limited dewpoint depression it affords, and its tendency to cause corrosion. In some cases, however, the 20 to 25°F. dewpoint depression possible with calcium chloride solutions may be adequate to protect the pipe-line system. In such cases the low cost of the material may offset its disadvantages. If the calcium chloride solution is used, the fractionating still as shown on the diagram is unnecessary, as the active material cannot be lost through vaporization. All that is required is a tub or tank with a heating coil in it to boil the required amount of water out of a small side stream of solution taken from the main circulation.

Nearly all the plants built during the last six years are using diethylene glycol as the dehydrating agent. This material makes possible dewpoint depressions in excess of 50°F. below contact temperature under usual operating conditions. It is non-corrosive and pleasant to handle. Where calcium chloride solutions show vicious corrosion of all the apparatus in the system even though small traces of oxygen or hydrogen sulphide are present in the gas, diethylene glycol remains non-corrosive even in the presence of appreciable amounts of both of these materials.

In cases where the dewpoint depression due to the water-absorbing property of the solution alone is not enough, the contact temperature may be lowered by circulating a large volume of cooled or refrigerated solution through the contactors. This method of cooling the gas by contact with the cold solution permits the attainment of temperatures that would not be possible with ordinary surface coolers applied to the incoming gas, because of the formation of hydrates in such coolers. If the gas is cooled by contact with cold dehydrating solution, hydrates will not form even under temperatures well below 0°F.[7]

Plants of this same type can be used for removing hydrogen sulphide and carbon dioxide from the gas, accomplishing at the same time a reasonable degree of dehydration. It is merely necessary to add one or more of the -ethanolamines to the diethylene glycol-water solution. Monoethanolamine is now in most common use for this purpose, although di- and tri-ethanolamine function in approximately the same way. The use of the -ethanolamines for this purpose, either separately or in combination with diethylene glycol, is covered by patents owned by the Girdler Corporation of Louisville, Kentucky.

In order to obtain the best extraction of the acid gases it is necessary to use a solution containing 10 percent or more of water. This reduces the efficiency of the mixture as a dehydrating agent but still allows a sufficient degree of dehydration to protect the pipe line in most instances.

Solid Adsorbent Systems[2]

A typical flow sheet for a plant using granular solid adsorbent material is shown in Fig. 2. Plants of this type have the advantage that they can accomplish a degree of drying far beyond anything possible with the hygroscopic liquid type plants. The moisture content in the gas can be made so small that it is not measurable, provided the adsorbent material is worked at reasonably low saturations.[2,16]

In such plants the adsorbent material is packed in beds in two or more shells (1) designed for the full line working pressure. The flow of gas into the line is passed through one or more such beds while the process of regeneration is going on in the remainder. Usually the adsorbent material is supported on grids spaced at intervals through the height of the contacting shell, in order to keep the thickness of any individual bed within reasonable limits to prevent crushing, and to insure even gas distribution.

The drying of an adsorbent bed after it has become saturated is usually done by passing hot gas through the bed in a closed circuit, as indicated in the flow sheet. (Fig. 2.) The drying gas is

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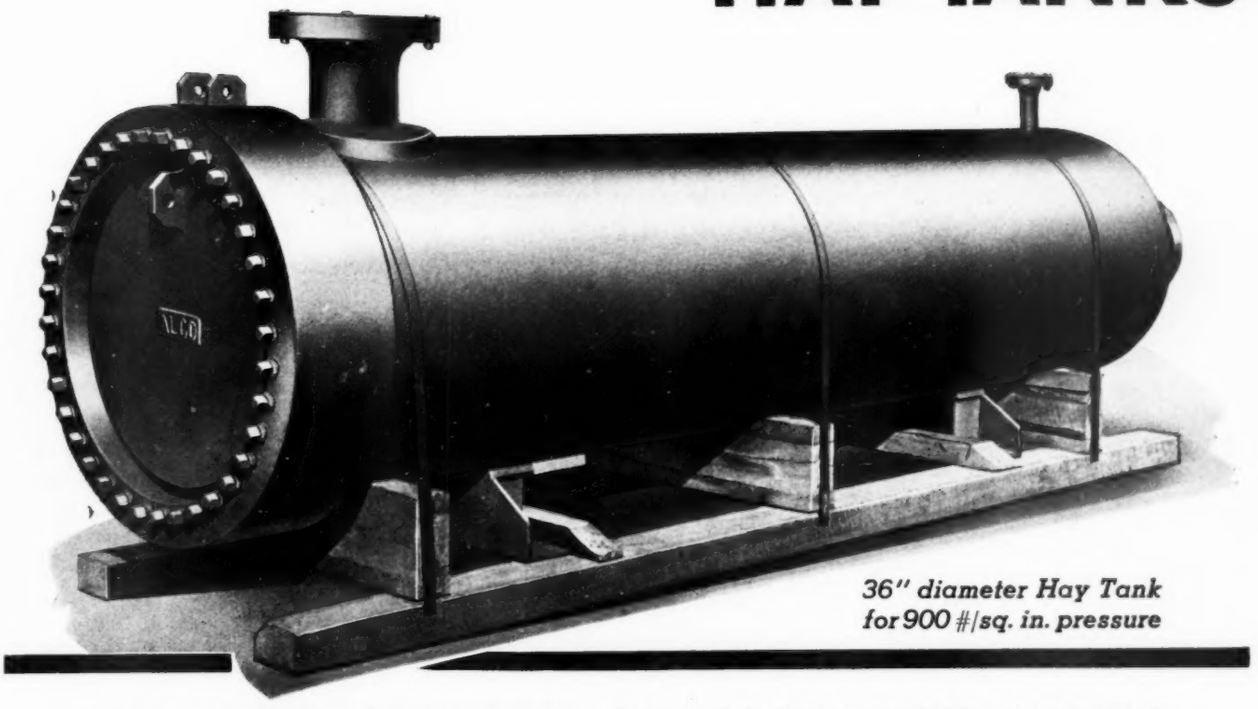

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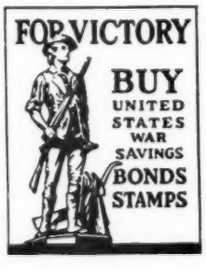

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pumped by the compressor or blower (2) through the heater (3) and into the adsorbent tower where the stream of hot gas gradually heats and dries out the adsorbent material. The water picked up by the circulating gas is condensed in the condenser (4) and removed through the separator (5). This process of regeneration is usually carried out at a pressure of not more than 50 to 75 lb. gauge regardless of the line pressure. The surplus gas, which must be removed from the contactor on high-pressure systems in order to get the pressure down to these levels, may be delivered into the general plant fuel system in advance of beginning the process of regeneration as indicated on the flow diagram. In special cases there may be a local use for part of the gas at reduced pressures so that it is unnecessary to provide a circulating pump or blower for the regeneration as shown in the flow sheet. Still another method of regeneration uses gas at full line pressure. This will require a somewhat higher temperature in the regeneration gas in order to obtain a given degree of drying in a given length of time.

Various granular adsorbent materials are available for use in systems of this type, namely, purified activated alumina, a grade of the same material sold under the trade name of Florite, silica gel, and partially dehydrated calcium sulphate.

Silica gel is not being used to any appreciable extent for pipe-line dehydration because of its tendency to disintegrate mechanically under the repeated heating and cooling required by this type of operation.

Partially dehydrated calcium sulphate is subject to the same mechanical objections as silica gel and is not capable of absorbing as much water as either the gel or alumina. So far as the writer knows, there have been no commercial applications of this material to the dehydration of natural gas for pipe lines.

The alumina drying materials are both being used successfully under conditions requiring the degree of dehydration they afford. Both activated alumina and Florite have good mechanical properties and do not appear to break up under repeated regenerations.

Operating Experience

The following discussion summarizes operating reports recently collected from various types of plants. Because of differences in accounting methods it is difficult to compare operating costs. Such figures should, therefore, be regarded only as rough approximations.

Calcium chloride brine plants. The largest plant still using calcium chloride solution went into operation in December, 1937, treating gas at a pressure of 500 lb. per sq. in. on the outlet of an absorption plant and a sulphur removal unit using the soda ash process. The operator states that a good deal of the mechanical troubles and deterioration of solution in the dehydration unit appear to have been caused by occasional accidental carry-over of slugs of soda ash solution from the sulphur removal unit, so that maintenance costs have been higher than they would have been if the plant had not been exposed to this interference.

The gas contains a trace of hydrogen sulphide (normally less than 0.5 grain per 100 cu. ft.) but contains no oxygen whatever, as all the gas sources originate under high pressure.

Processing an average of about 73,000,000 cu. ft. per 24 hours, the plant showed a total cost last year of $5795 for operation and maintenance, or 21.8 cents per 1,000,000 cu. ft. of gas treated. These costs include an annual charge of about $3000 for prorated operating labor, water, power, and plant overhead. No charge is included for taxes or depreciation.

The operator states that a definite increase in pipe-line capacity was noticed after the plant was placed in operation and ascribes this increase to the elimination of condensed water from the line. No definite figures bearing on this increase in capacity were given.

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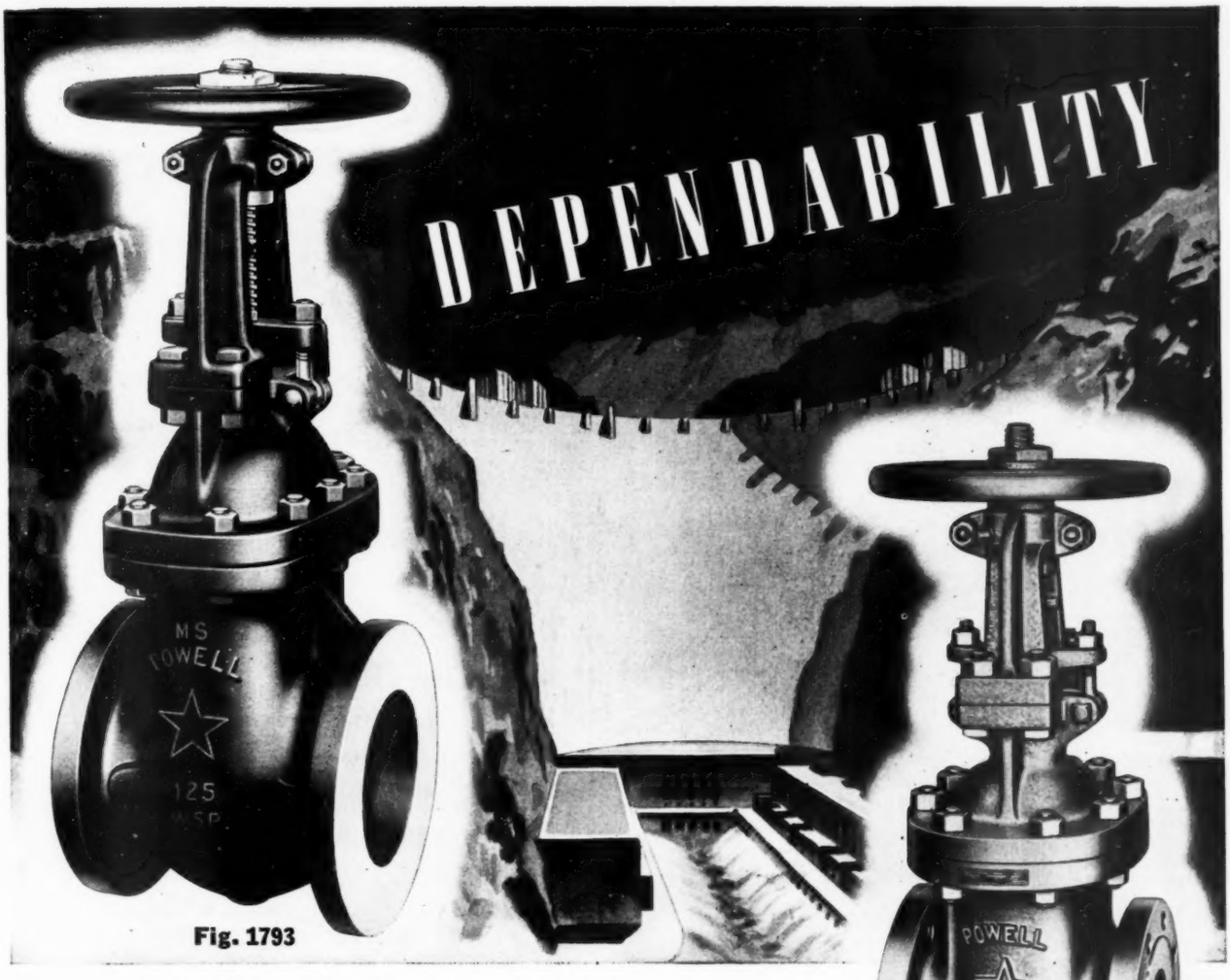

Fig. 1793

Fig. 1503

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Fig. 1503—Class 150 pounds Cast Steel Gate Valve with flanged ends, outside screw rising stem, and bolted flanged two-piece yoke bonnet. Available in sizes 1″ to 24″, inclusive.

Fig. 1793—A large size Iron Body Bronze Mounted Gate Valve with flanged ends, outside screw rising stem, and taper wedge solid disc. Made in sizes 2″ to 30″, inclusive, for 125 pounds W. P.

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The average dewpoint depression accomplished is 20°F., which adequately protects the system against hydrate formation except under occasional temporary and unusual weather conditions.

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EDITOR'S NOTE: This article will be continued in an early issue.

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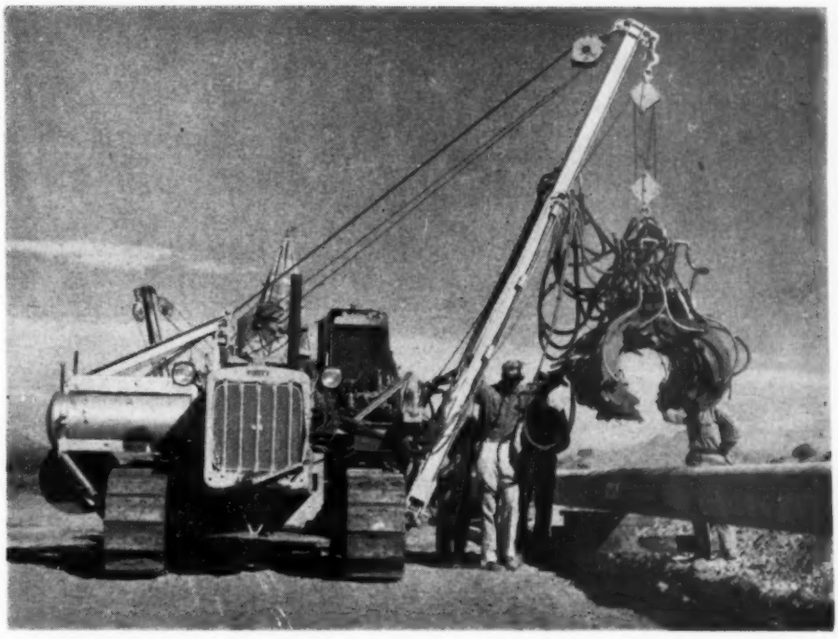
A 16-in. pressure welding clamp being placed on the line



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Pressure Welding of Pipe Lines

☆ Details of method devised by El Paso Natural Gas Company

by A. L. Forbes

Vice-President and General Superintendent, El Paso Natural Gas Company

THE possibility of welding pipe lines by the pressure welding method was first considered in the early part of December, 1940. At that time this method of welding was being successfully used for welding tool joints to drill stems. This service, of course, is considerably more exacting than pipeline welding. Although the equipment for welding tool joints was stationary, the preparation of the ends to be welded was both precise and tedious.

Obviously the equipment for welding pipe lines had to be light and mobile and unless the process permitted considerably more tolerance in end preparation than was required in welding tool joints, such a method would be neither feasible nor practicable. A pressure weld clamp having these characteristics was designed and constructed for 6⅝-in. pipe by the El Paso Natural Gas Company at its El Paso, Texas, machine shop. Numerous test welds were made in the company shop with this clamp.

At the beginning of the test, certain principles, thought to be essential, were set forth and followed throughout all tests.

1. The ends of the two pipes to be welded had to be perpendicular to longitudinal axis of the pipe (pipe not beveled).

2. The ends of the pipe had to be smooth and without tool marks.

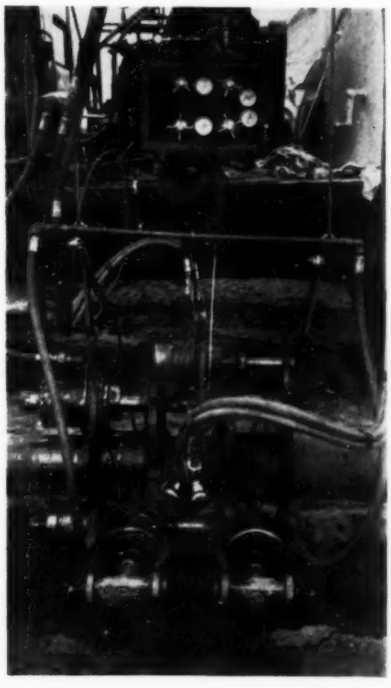
3. The ends had to be free from dirt, rust or grease.

4. A small tolerance was permitted for out-of-roundness of the pipe as well as a difference in the O. D. of the two ends of the pipe to be welded.

5. The metal could not be permitted to run.

It was also assumed that successful welding could be accomplished by either a single "Endo" total pressure of approximately 16,000 lb. applied to the ends to be welded at the start of the heating, or by applying an initial total pressure of approximately 4000 lb., and after the ends were sufficiently heated, suddenly applying the 16,000-lb. total pressure.

A 6-in. clamp on line



First Field Test

Tests made in the shop showed that larger tolerances were possible in regard to out-of-roundness as well as differences in the O. D. of the two pipes. Ac-

A 10-in. pressure welding clamp with sideboom tractor and trailer

cordingly, it was decided to make an actual field test by welding 1.88 miles of 6⅝-in. pipe with wall thickness of 0.1875 in. This line extended from our main line near Tucson, Arizona, to the Davis Monthan Air Field.

The pipe mills were instructed to ship the pipe with straight ends without beveling. A truck was equipped to carry the clamp, acetylene generator, and oxygen bottles. A power take-off was constructed to drive the necessary hydraulic equipment and water-cooling system. A picture of the truck together with the clamp and control board maintained on the truck is shown in an accompanying photograph. The principles set forth for the shop tests were strictly adhered to and the field test proved so successful that the problem of welding in the field was considered solved, and that in order to weld larger diameter pipe, it was only necessary to build a larger clamp.

Larger Clamp Constructed

Construction of another clamp of similar design to weld 10- in. or 12-in. pipe was immediately begun. Experience with the 6-in., however, had shown that a truck would not be suitable for maintaining the heavier weight 10-in. or 12-in. clamp, nor would it be practical for use in rough mountainous country. In place of the truck, a 40-hp. sideboom tractor was equipped with the necessary hydraulic equipment and water-cooling system. Both were driven by power supplied by the cat engine. A trailer carrying the acetylene generator and the oxygen bottles was attached to the cat. The cat driver operated the hydraulic levers in order to give the required pressures to the clamp.

The construction program of the company called for the building of some 10¾-in. loop lines to its system in Arizona. The pipe mills were instructed to ship the pipe with ends prepared for pressure welding similar to that of the 6⅝-in. pipe previously laid. Actual construction of this loop line began in April, 1941, and although the equipment performed satisfactorily using the same procedure as on the original 6⅝-in. line, the results were erratic; that is, a series of good welds would follow a series of bad welds, with no deviation from the procedure. After checking, it was found that the ends of the pipe were not perpendicular to the longitudinal axis. A portable grinder was then made in an effort to correct this condition and with the use of a steel square the ends of the pipe were made perfectly square before being placed in the clamp. This, however, did not entirely eliminate the bad welds and it was decided that it was impracticable to grind the ends in the field to the degree of accuracy that was necessary. After welding approximately 10 miles of this line, the machine was returned to El Paso for further experimental work.

The clamp was rebuilt and strengthened and after numerous tests it was found that consistently good welds could be made with square cut ends (no bevels) provided the principle of applying first the low endo and later the high endo pressures was adhered to. The single high endo pressure method caused the pipe ends to upset slightly prior to the time such ends had reached the proper temperature and thus created inconsistent results. It was decided, however, that this method of welding would be impracticable if the ends of the pipe required such precise preparation. All tests showed that weld failures in every instance had been due to a slight inside bevel of the pipe ends, invisible to the eye, that caused the formation of oxides. The presence of the oxides prevented the ends being welded when such oxides occurred. In order to eliminate the inside bevel, joints were prepared in a lathe having a one-degree outside bevel that later was increased to three degrees. All welds made on pipe with some outside bevel passed a 180-deg. bend test and the pull test, but a

Clamp, acetylene generator, oxygen bottles, and control board mounted on truck

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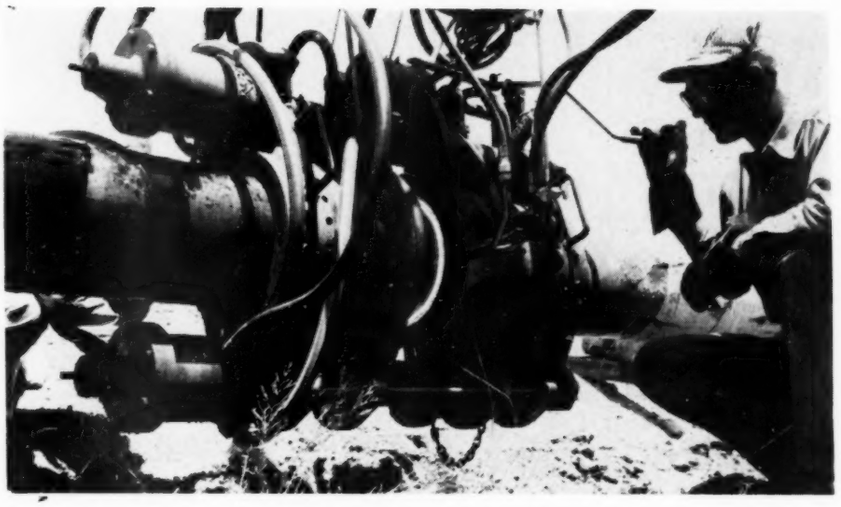

Operating a 10-in. pressure welding clamp

bevel of two degrees resulted in more satisfactory tests.

16-in. Clamp Made

At this time the company had approximately 70 miles of 16-in. line to lay and work was begun on the construction of a 16-in. clamp. Numerous changes in design were made, the principal one being an arrangement to round up the ends of the pipe. The mill was advised to ship the pipe with a two-degree outside bevel making an included angle of four degrees.

Using the two-degree bevel and the low initial and the high final endo pressure, all the 16-in. line was laid with the pressure weld method of welding. The line has been in continuous operation since November, 1941, and to date there has not been a break or leak in the entire 70 miles. Since that time approximately 150 miles of pipe lines have been welded for the company ranging from 6⅝-in. to 16-in., all of which have given satisfactory service.

Use on Reclaimed Pipe

During the summer of 1942, numerous pipe lines were being laid using old reclaimed pipe, some of which was originally screw pipe. Because of the scarcity of welding rod, the company was asked to determine whether torch-cut pipe ends could be successfully welded by the pressure weld method. By smoothing up the torch-cut pipe ends with a hand grinding tool and using 36 grit fiber combination disks, it was found that satisfactory welds could be consistently made. It was also found that increased production together with better uniformity of welds could be obtained by increasing the bevels of the pipe ends to eight degrees making an included angle of 16 degrees. During the last few months, this method of welding has been used by the company for an outside oil company on welding approximately 140 miles of 8⅝-in. pipe and approximately 60 miles of 10¾-in. pipe. All the pipe used was reclaimed pipe with ¼-in. to ⅜-in. wall thickness and was prepared with torch-cut bevels.

Practically all the trouble now encountered with the pressure welding method are attributed to the bronze burner head that supplies a mixture of oxygen and acetylene and the medium of heating the ends of the pipes. These troubles are being overcome, however, by providing spare burner heads for the various clamps as rapidly as priority can be procured for obtaining critical material necessary for their construction.

Features of Method

The principal features of the pressure welding method may be summarized as follows:

1. Welding rod is not used.
2. All welds made are bell-hole welds and permit use of the stove-pipe method of laying pipe lines. This in turn materially reduces the number of men and amount of equipment necessary.
3. The time required to weld does not increase with the diameter of the pipe. A weld on a 24-in. pipe requires the same time as that on a 6-in. pipe of equal wall thickness.
4. The same number of men are required to operate the clamp regardless of the diameter of the pipe.
5. Actual welding experience has shown that a pipe having a wall thickness of 0.1875 in. required approximately 35 seconds of actual heating time and a pipe having a wall thickness of 0.375 in. required 90 seconds of actual heating time.

It is hoped by those who have been interested in developing this method of welding that the use of such process will make possible the construction of necessary pipe-line projects that have been held up due to difficulty in obtaining welding rod made scarce by the heavy demands of ship building industries and thereby in a small way contribute to the war effort.

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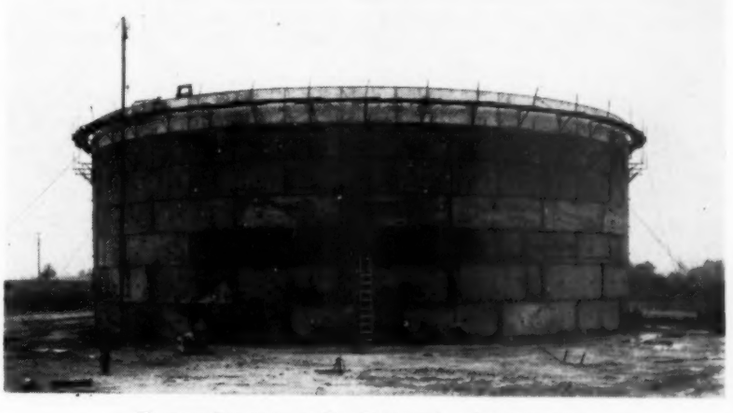

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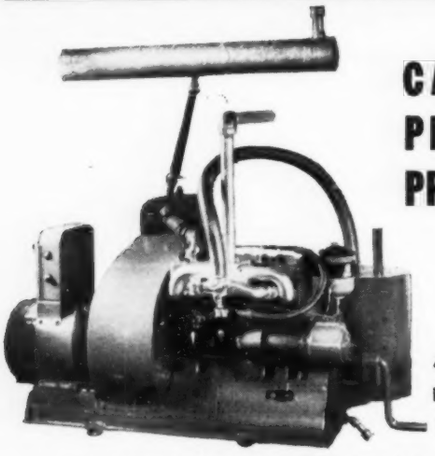

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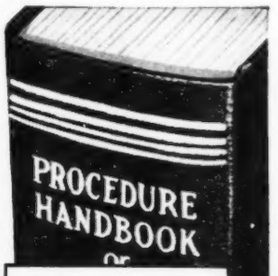

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by Charles E. Erb

Technologist, D. W. Haering and Company, Inc.

IT is the purpose of the writer in this series of articles to survey the problems arising from improper water conditions at oil pipe line and gas compressor stations, and to point out how these problems may be solved with the expenditure of little, if any, capital for equipment; equipment that is practically unobtainable at the present time. Where such equipment is already in use, results are seldom completely satisfactory. Such conditions can be improved by proper study and intelligent application of chemicals now available. Scale, corrosion, and various microorganisms are the saboteurs that necessitate replacements, lowered efficiency, decreased throughput, and increased operating costs. Thus it is necessary to study in detail these enemies, and to eliminate or minimize their effects. Rohrdanz[1], and Wedell and Borst[2] have discussed the economics of water conditioning very forcibly.

Whether the pipe line is handling crude oil, refined products, or natural gas, these problems exist, differing mainly in details. In addition to difficulties encountered at the stations along the line, problems exist within the pipe lines themselves. The major problems here are the maintenance of normal flow without increasing pressures, and reducing pipe replacements by elimination of corrosion, internal and external. The prevention of external corrosion of pipe does not properly come within the scope of this article. It might be well to mention, however, that a protective coating for external application, incorporating a corrosion inhibitor also used in water treatment, has been developed and is highly effective.

CHARLES E. ERB

entered the School of Engineering of the University of Missouri shortly after World War I, taking work leading to a B.S. degree in chemical engineering—His first position in industry was as plant control chemist for Wilson and Company, Oklahoma City—Left Oklahoma City in 1924 to return to his home town of St. Joseph, Missouri, as chief chemist for a commercial testing laboratory—In 1931, entered the commercial laboratory and consulting field in Wichita, Kansas—In 1937, became associated with D. W. Haering and Company, Inc., acting as director of the Wichita Division laboratory—In 1941, became Wichita district manager, supervising activities and service in Kansas, Oklahoma, Nebraska, and the Texas Panhandle—Is now technologist for the company, making his headquarters in Chicago.

Internal corrosion of pipe lines is more important from the standpoint of decreasing flow than from causing replacement of piping. Increased friction losses due to corrosion products forming within the lines, may seriously lower the throughput, or increase pumping costs by making necessary the application of increased pressures. Because of the fact that the presence of moisture in the gaseous or liquid hydrocarbons has been found necessary for the progress of corrosion, the addition of a water-soluble inhibitor injected into the lines provides a practical and economical approach to the solution of this problem. Oxygen, carbon dioxide, hydrogen sulphide, and other corrosive sulphur compounds are factors in the problems of internal corrosion in pipe lines. Analyses of condensed moisture taken from drips or traps along the line will dictate the proper choice of an inhibitor to overcome the effects of these contaminants.

Although the same broad principles apply to water treatment for any type of plant or equipment, a complete discussion of the subject resolves itself into three main divisions: first, the consideration of the water characteristics and operating conditions leading to scale, corrosion, algae and bacterial deposits, etc.; second, problems peculiar to certain types of systems involving the use of water, such as engine and compressor cooling systems, gas coolers, and boilers, and third, a study of natural gas, gasoline and other refined products, and crude oil pipe lines, all of which differ in the type of equipment as well as in operating details. This first article will deal with water problems in a general way, and with methods used successfully to overcome difficulties that arise.

Scale Formation

No attempt will be made to review all the various reactions involved in water chemistry and treatment. Standard reference books on the subject are generally available, and many technical articles have appeared in the scientific and trade journals, dealing with special

1. "Economics of Water Conditioning for Scale and Corrosion Control," R. C. Rohrdanz, *The Petroleum Engineer*, May, 1942.
2. "Increasing Production with Clean Condensers," C. L. Wedell and W. B. Borst, *Refiner*, August, 1942.

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phases. The term "scale" usually means deposits resulting from precipitation from the water of substances of low solubility, which are rendered insoluble by increased temperatures and/or concentration, or by oxidation or other chemical reaction. The character of the scale is altered by the temperatures prevailing in the equipment, and by the presence of oil, corrosion products, sand, silt, and various types of organic matter, including algae and bacterial debris and chemicals used for treatment. Scale, in the true sense of the word, is a crystalline deposit, but the presence of various substances in the water may serve as a binder for small crystals, which would not otherwise form adherent scale. On the other hand, the presence of certain chemicals, added for that specific purpose, will so affect the nature of the precipitated substances that a non-adherent sludge, amorphous in nature, rather than a crystalline scale, is formed.

Calcium carbonate ($CaCO_3$) in the form of calcite or aragonite, is the constituent of scale most commonly found, due to the fact that practically all natural waters contain calcium bicarbonate $Ca(HCO_3)_2$, which readily breaks down at low temperatures to the soluble normal carbonate. Calcium sulphate ($CaSO_4$) is another common offender, and can be very serious when temperatures are high and the water is originally high in this constituent and is concentrated to a considerable extent. Magnesium oxide (MgO), magnesium hydroxide $Mg(OH)_2$, and magnesium carbonate $MgCO_3$, are present in many scales. Iron is found as the sulfide (FeS_2), as well as in the form of various oxides. When phosphates are used for treating the water, phosphates of calcium, magnesium, or iron may form scale. Silica may be present in various forms, including silicon dioxide and various complex silicates containing calcium, magnesium, iron, aluminum, and even sodium. These latter complex compounds are of the general nature of zeolites used for softening water. Aluminum is often present due to the use of alum or aluminate for coagulation.

Williams[3] in an article devoted to chemical scale removal, lists a number of scale constituents, the equipment from which the deposits were taken, and the chemical formula of the crystalline minerals formed. The use of X-ray analysis, as described by Hannawalt, Rinn, and Frevel[4], was resorted to

3. "Chemical Removal of Scale from Heat-Exchange Surfaces," Guy F. Williams, *Power*; January, 1943.

4. "Chemical Analysis by X-Ray Diffraction," J. D. Hannawalt, H. W. Rinn and L. K. Frevel, *Industrial and Engineering Chemistry* (Anal. Ed.), September 15, 1938.

in order to establish definitely the exact constitution and formula. Haering[5], gives the accompanying table showing hypothetical combinations from the ionic analyses of scale samples from various parts of engine and compressor cooling systems. (Table 1.)

As was noted before, calcium carbonate will deposit at comparatively low temperatures and concentrations. The precipitation depends also on the concentration of carbon dioxide in, or in in contact with, the water, and on the pressure. The International Critical Tables[6] give detailed data on equilibrium relationships. From the chemical equation:

$$CaCO_3 + H_2O + CO_2 = Ca^{++} + 2(HCO_3^-)$$

the equilibrium constant becomes

$$K = \frac{^c(Ca^{++})\,XC^2\,(HCO_3^-)}{^c(CO_2)}$$

where:

K = equilibrium constant
$^c(Ca^{++})$ = concentration of calcium ions (mols per liter)
$^c(HCO_3^-)$ = concentration of bicarbonate ions (mols per liter)
$^c(CO_2)$ = concentration of carbon dioxide (atmos. partial pressure)

Langelier[7] has developed a formula and method for showing the carbonate stability and corrosive properties of a water, using the content of dissolved solids, total calcium, total alkalinity, and pH of the water as factors. Hoover[8] has developed a nomographic chart to facilitate calculations using this formula. De Martini[9] has shown that good checks can be obtained on municipal supplies, where lime treatment is generally used. Attempts have been made to apply this formula to the control of cooling water conditions with varying success. Free carbon dioxide, until driven off from the water by heat, prevents deposition of carbonates, but causes a low pH and a corrosive condition. Other salts present in the water, particularly magnesium salts, as well as organic materials, would influence conditions, and make difficult the interpretation of results. Another factor may influence results. At the beginning of a zeolite softener run the effluent water is practically free from carbon dioxide, whereas at the end of the run the zeo-

5. "Experimental Cooling Systems," D. W. Haering, *Industrial and Engineering Chemistry*, November, 1941.
6. *International Critical Tables*, Vol. VII. McGraw-Hill Book Co., Inc., New York, N. Y.
7. W. F. Langelier, *Journal American Water Works Association*, 28, 1500 (1936).
8. Chas. P. Hoover, *Journal American Water Works Association*, 30, 1802 (1938).
9. DeMartini, *Journal American Water Works Association*, 30, 85 (1938).

Pipe Line

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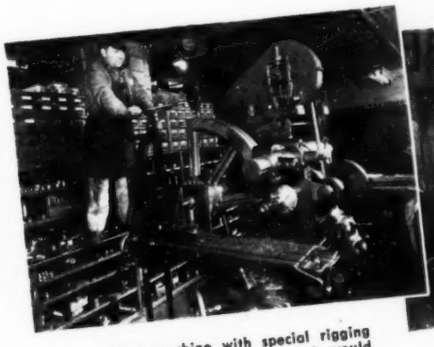

A milling machine with special rigging machines odd-shaped parts that would have required several separate machining operations and welding.

A slotting machine with small electric motor attached to drive the cutter, takes the place of a milling machine on this job.

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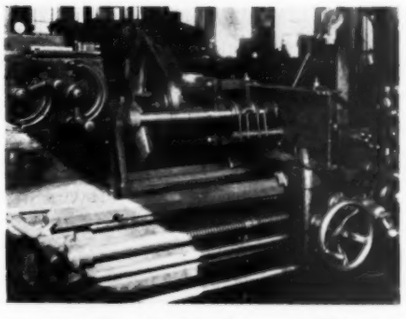

Engine lathe with improvised fixtures and I-beam extensions being used on a drill press or milling machine job.

A difficult horizontal boring mill job being done on an engine lathe. Note how raising blocks lift the spindle so that the job will clear the carriage.

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TABLE I
Deposits in cooling systems (percent)

	Gas engine cylinder	Discharge outlet from piston	Compressor jacket	Cooling tower woodwork	Engine jacket	Combustion-head jacket	Exhaust head	Piston rod
$CaSO_4$	1.10	0.55	26.72	None	4.14	2.80	3.19	1.96
SiO_2	15.30	58.50	19.54	0.46	2.96	1.72	5.22	1.19
$CaCO_3$	60.60	21.30	14.86	53.40	75.30	80.50	64.86	57.55
$MgCO_3$	10.40	0.50	10.36	Trace	None	None	10.85	1.40
Fe_2O_3	2.06	2.90	13.55	None	6.00	5.43		29.18
$Ca_3(PO_4)_2$	0.03	None	None	Trace	None	1.65	0.41	None
FeS	None	None	None	None	None	None	6.17	None
Oil	None	None	None	None	None	None	7.64	None
Volatile and organic	5.30	13.40	9.40	2.40	4.09	4.11	1.29	5.60
Moisture	1.60	2.13	4.00	42.90	3.65			
Undetermined	3.61	0.72	1.57	0.84	3.95	3.79	0.37	3.12

lite releases carbon dioxide previously removed. This variable content of carbon dioxide and changing pH might upset calculations based on Langelier's formula.

Getting back to the practical, the following figures will show why calcium carbonate deposits are common. An average natural water, containing about 10 grains per gallon (171 p.p.m.) of calcium bicarbonate (as $CaCO_3$) and in contact with air containing normal quantities of carbon dioxide, will begin to deposit calcium carbonate at a temperature of about 130°F. At 180°F. about 20 percent of the total calcium bicarbonate would deposit. If the calcium bicarbonate content were doubled, precipitation would begin at about 120°F. It must be realized that skin temperatures where water contacts hot metal surfaces are much higher than that of the body of cooling water. This is particularly true in engine and compressor cooling systems. Calcium carbonate, if precipitated in a pure state, may not form adherent scale, but usually some cementing material is present.

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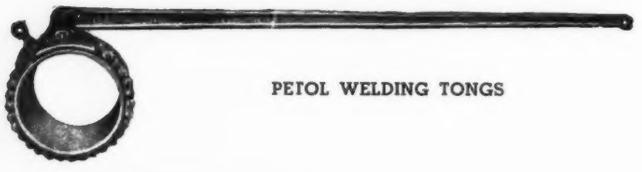
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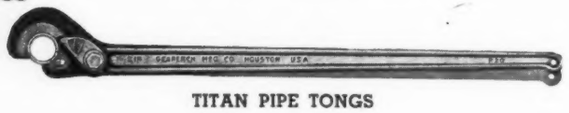
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Water for Pipe-Line Stations

When water is softened for use in pipe line stations, zeolite softeners, rather than lime, or lime-soda, are used. This type of unit, using natural or manufactured zeolite, merely converts the calcium and magnesium salts to sodium salts. Some few stations use a new type of base exchange material regenerated with acid instead of sodium chloride brine. This material is of a carbonaceous nature. The effluent will then contain carbonic acid rather than sodium bicarbonate, such as occurs with the salt regeneration. This carbonic acid must be removed by heat and aeration, to avoid serious corrosion trouble. Softened water is used for make-up for either open or closed engine-cooling systems, gas-cooling units, boilers, etc.

Lime treatment will remove, in large part, the carbonate hardness due to calcium and magnesium bicarbonates. It will also precipitate as magnesium hydroxide the hardness due to the presence of any magnesium chloride, sulphate, or nitrate. The additional use of soda ash will remove non-carbonate hardness caused by calcium chloride, sulphate, or nitrate. These processes have the disadvantages of difficulty of control, of requiring equipment of considerable size and complexity, and of finding means of disposing of considerable amounts of sludge formed in the softening process. Unless the hot process is used, reactions are incomplete and settling time is slow, necessitating large settling basins or tanks. Various coagulants are used to speed up clarification, and pressure filters are generally necessary. Recent innovations provide for removal of silica in the raw water supply. As noted before, few pumping stations use lime or lime-soda ash, and the reasons are obvious.

Carbonate hardness can therefore be removed by either the zeolite or lime process, and calcium carbonate scale materially reduced. Another method sometimes employed in cooling waters is treatment with sulphuric acid, to convert the major portion of the calcium and magnesium bicarbonates to the more soluble sulphates. This practice has certain disadvantages that detract from its desirability. Serious injuries may occur to operators, due to accidents in handling the acid. The calcium content of the water and its tendency to deposit calcium sulphate scale are greatly increased. Very close control of concentrations and alkalinities are necessary to prevent scale formation or serious corrosion of equipment. In one engine cooling system using acid, a pH of 4.1 and a mineral acidity of 110 parts per million were found.This is not at all unusual where control is not carefully watched. Haering [10] discusses the subject of acid treatment exhaustively, comparing it with other methods for cooling water conditioning. He recommends the use of chrom glucosates to eliminate corrosion, and the close control of dissolved solids in the water.

Calcium sulfate scale is harder and denser than carbonate scale. As calcium sulphate has an inverse solubility curve, it becomes less soluble at high temperatures. At the temperatures prevailing at many heat exchange surfaces, calcium sulphate will readily deposit, particularly if present in high concentrations. Such deposits are particularly troublesome in engine and compressor jackets, and in high-pressure boilers. Many natural waters are high in calcium sulphate content. In the case of a small gas compressor plant in Oklahoma, well water containing about 1026 p.p.m. (60 gr. per gal.) of calcium sulphate in addition to about 342 p.p.m. (20 gr.p.gal.) of other encrustants, was used as make-up for the engine cooling system. Within the course of a month or so scale ½ to 1 in. in thickness had deposited in the jackets, resulting in overheating and necessitating a major overhaul. Acidizing of the system with hydrochloric acid failed to remove this scale.

Silica is present in water, often in considerable amount. In western Kansas, New Mexico, and other areas, it is not unusual to find silica contents of 85 to 120 p.p.m. In scale the silica found may be present in various forms, due to precipitation from the water, or it may be found as fine particles of sand or soil, or it may be due to diatoms. Silica scale is unusually hard and dense, and has a high heat insulating value. The use of sodium silicates for water treatment is ill-advised, in most cases, and aggravates silica scale trouble.

Various forms of iron oxides and hydroxides, either from precipitation from the make-up water, or from corrosive processes, are found in scale deposits. Where sulphur compounds are present in the water, iron sulfide may result. Aluminum compounds are usually a minor factor. Sodium compounds, which are highly soluble, may be found on hot surfaces where, due to evaporation, they are left behind such as on tube bundles and coils in cooling towers, where the water is not in continuous contact with hot surfaces.

Haering[5, 10] lists a number of typical analyses of cooling waters and make-up waters, and describes results attained with the use of beta glucoside and tetraphospho glucosate in the control of scale in experimental cooling systems. These organic chemicals were compared with an inorganic phosphate also used for this purpose. Dosages as low as 2 p.p.m. (1 lb. to 60,000 gal. of water)

10. "Scale and Corrosion Studies," D. W. Haering, *Industrial and Engineering Chemistry*, November, 1941.

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were found to decrease scale materially as well as to reduce corrosion. Practical applications in many plants have confirmed the experimental results. When corrosion is severe, sodium chrom glucosate, quachrom glucosate, ferrichrom glucosate, or cupric chrom glucosate are efficacious. Cupric chrom glucosate is of particular value where algae or bacteria are contributing to the problem. Sodium glucosate is more highly alkaline than the other chemicals mentioned, and is valuable for pH as well as scale control.

For rapid removal of scale, hydrochloric acid, with or without an inhibitor added, is commonly used. Chrom glucosates are highly effective inhibitors for this purpose, and reduce solution of metal to a minimum. Special acid cleaners are necessary, in many cases, due to the nature of the scale deposit. On a cleaning job, it is necessary to take into account the type of equipment, the various metals in the system, and other factors, in addition to the chemical analysis of the scale.

Most of the discussion has dealt with scale in cooling systems. A few pipe line stations use steam for power, and many have low-pressure steam boilers for heating. Both high- and low-pressure boilers may be kept operating at high efficiency for long periods with the chemicals previously mentioned.

Corrosion

The electrochemical theory of corrosion is most generally accepted as explaining satisfactorily most of the phenomena involved in corrosion processes. Simply stated, corrosion occurs due to the tendency of metals to dissolve in water or aqueous solutions. Oxide films that form on the metal surface sometimes protect the metal from further attack. Under ordinary circumstances, these films are either destroyed, or they are penetrated by liquids or gases, thus permitting the corrosion to proceed. Oxygen, carbon dioxide, hydrogen, and other corrosive gases, as well as corrosive salts and acids, play a part in increasing corrosion. Galvanic action, graphitic corrosion, erosion, cavitation, impingement attack, all contribute to the complexity of the problem. Mechanical or chemical removal of dissolved gases may solve the problem in some cases. In cooling systems the use of chrom glucosates, which form durable and self-healing protective films, is usually effective. Haering[11] has shown the application and control of film inhibitors of this type. Corrosion is commonly found in engine jackets, heat exchangers, condenser tubes, boilers, etc.

Algae and Bacteria

In recent years, increasing attention has been given to the control of algae and bacterial growths in cooling systems. The many different types found make it necessary to consider each case individually. Chlorine, chloramine, copper sulphates, chromates, permanganate, chlorinated phenols, and other chemicals have been employed in combating these troublesome microorganisms. Cupric chrom glucosate and quachrom glucosate, widely used for this purpose, have the advantages of being non-volatile, of low toxicity, and of combining scale and corrosion control with control of algae and bacteria. It must be remembered that all three factors are interconnected.

Summary

A general discussion of the principles governing the control of scale, corrosion, and algae control has been given. The discussion, although by no means complete, attempts to cover most of the important problems encountered in water systems in pipe line stations, and mentions chemicals that are available and are employed to remedy unsatisfactory conditions. In most cases, installation of additional equipment is unnecessary. Subsequent articles will deal more specifically with various types of water systems and pipe line stations.

11. "Film Inhibitors in Industrial Aqueous Systems," D. W. Haering, *Industrial and Engineering Chemistry*, December, 1938.

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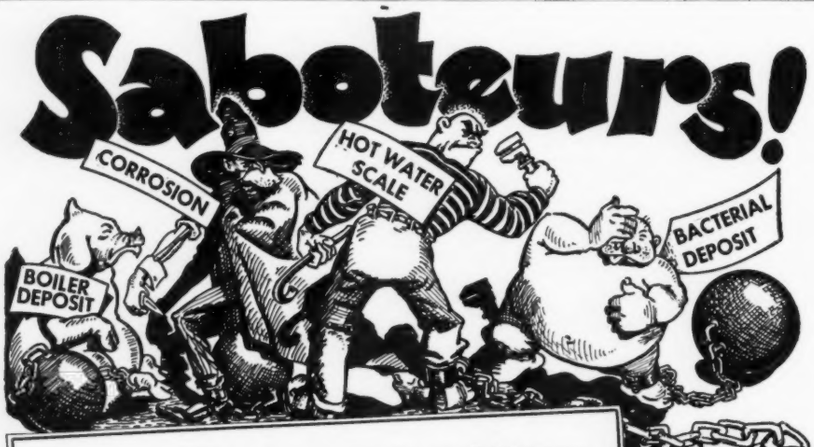

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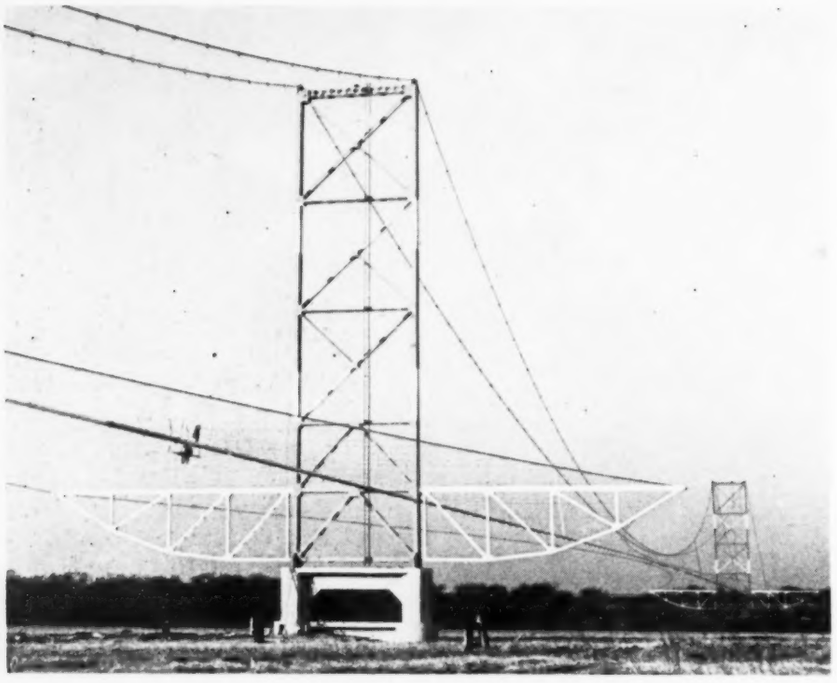

General view of pipe-line suspension bridge over Canadian River, Oklahoma

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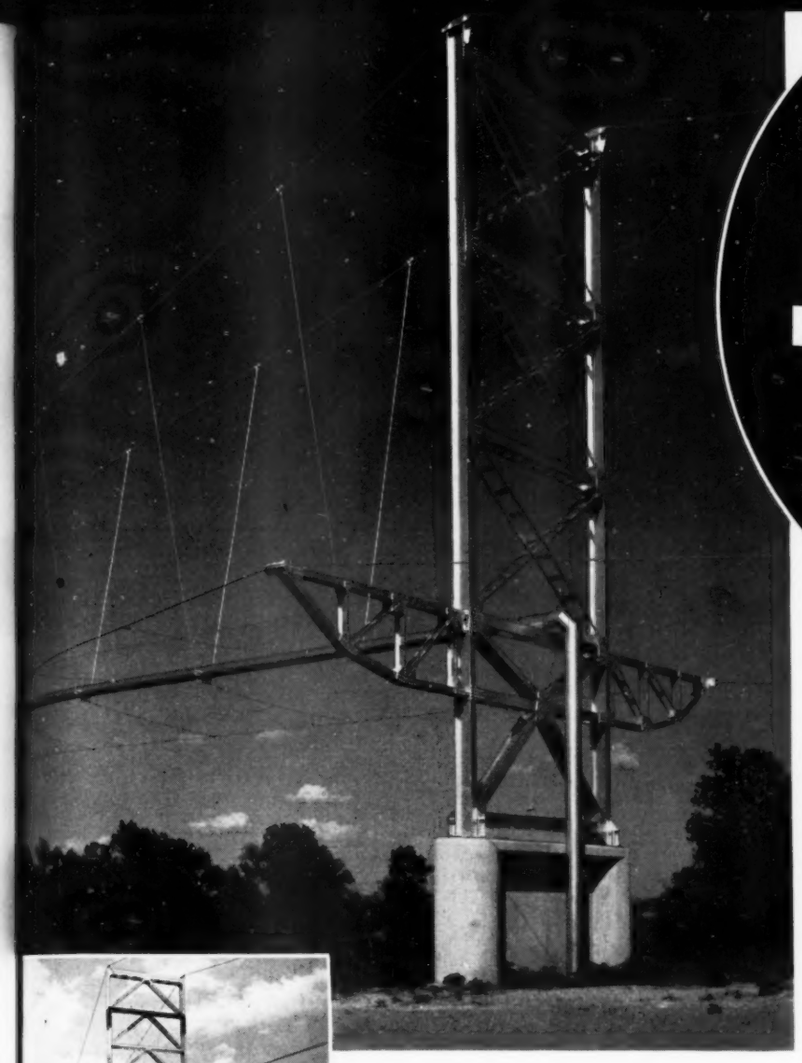
GORDON R. LUNT

was graduated in engineering from the University of Iowa in 1921, and received his C.E. degree in 1927—Became associated with the Pittsburgh-Des Moines Steel Company, Des Moines, Iowa, in 1922, and has been manager of the Bridge Department since 1928—Has had 13 years' experience in the development and construction of pipe-line suspension bridges.

and awarded the Pittsburgh-Des Moines Steel Company, Des Moines, Iowa, a cost-plus contract to construct these two bridges in their entirety including the erection of the pipe line on both structures, and retained the welding of the pipe for their own organization.

After the approximate location was selected for each bridge, several profile surveys were made from which the exact location was selected by the engineers, and as soon as they had determined the type, length of spans, location of the piers and anchorages for the South Canadian River bridge, test borings were made. From the test logs the engineers completed the designs of the anchorages, which permitted the beginning of construction several weeks in advance of the completion of the design of the entire structure. The towers and cables were then designed so materials could be ordered, stock reserved, and shop details begun. Next, the piers were designed so their construction could be carried on simultaneously with the anchorages.

The North Canadian River bridge was handled in a similar manner, so that construction could be carried on while



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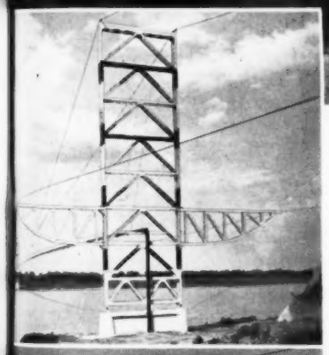

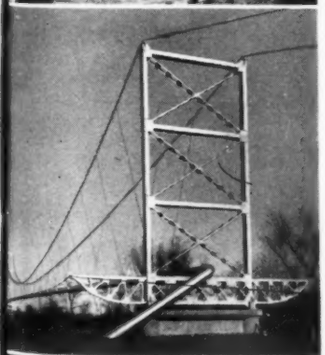

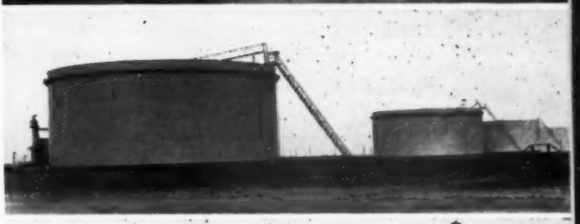

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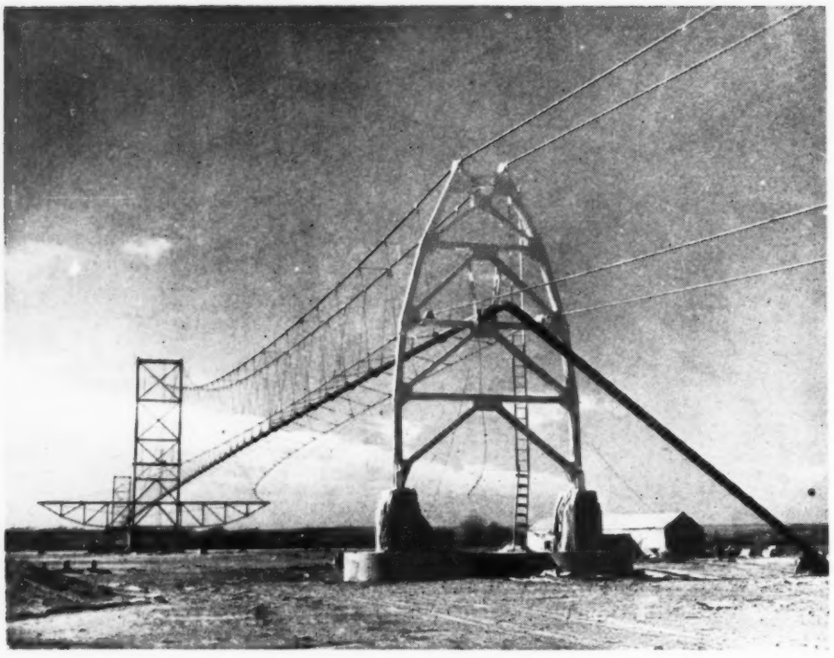


In foreground are shown the rest tower and pipe arrangement. The two main towers are in background

the engineers completed their final design drawings.

South Canadian Bridge

The South Canadian River bridge has a length, face-to-face of anchorages, of 3618 ft., a main span of 1760 ft., with one side span of 880 ft., making a total loaded length of 2640 ft. This bridge has the distinction of being the longest span pipe-line suspension bridge in the world and the longest span bridge in the world employing multiple-strand main cable construction.

The anchorage on the high side consists of two independent concrete anchorages 35 ft. long, 10 ft. wide, and 16 ft. deep, founded on red bed, into which steel piles were driven within the concrete area to act as keys. The single concrete anchorage on the low side is 40 ft. long, 16 ft. wide, and 16 ft. deep, and is founded on steel sheet pile, driven 40 ft. below water line into red bed, which are electrically welded to steel wales imbedded in the concrete, thus making the steel sheet piles serve a dual purpose; namely, acting as bearing piles as well as a cofferdam that should prevent any possible scouring under the anchorage.

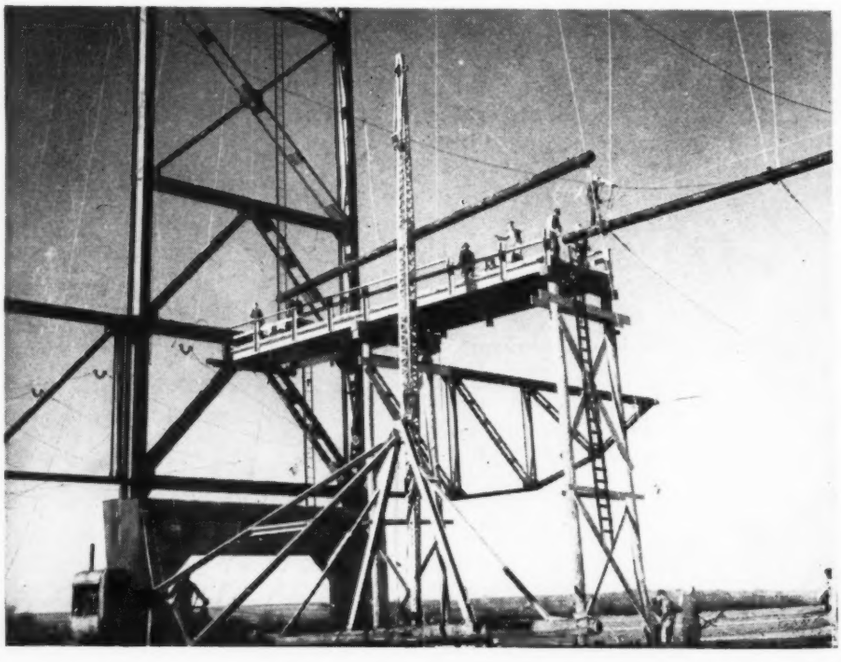
Each pier base of the two main piers and the one rest pier consists of two concrete caissons, each having a 12 ft. outside and an 8 ft. inside diameter, and each provided with a heavy steel cutting edge. These caissons were carried to a maximum depth of 48 ft. 6 in. below grade, then 10 ft. diameter keys were cut into the red bed to a depth of 4 ft. below the cutting edge, making the total maximum depth to the bottom of footings 52 ft. 6 in.

All caissons were sunk by the open dredging method until red bed was encountered, then it was necessary to dewater them and use paving breakers and buckets to remove the excavated material. As it was necessary to keep the caissons heavy in order to force them into the red bed to obtain a water cutoff as well as overcome friction, an additional 200-ton load was applied to each caisson by the use of a load box. Provisions were made in the design and construction of the caissons so that they could be converted to pneumatic caissons if difficulties were encountered.

Upon completion of the keys below the caissons, seal courses were poured in direct contact with the red bed by use of a tremie after which the caissons were filled with lean concrete. The solid top course with connecting struts between the two caissons was next poured, which in the case of the pier on the high side completed the pours, whereas pier tops were necessary for the piers on the low side to bring them to proper elevation.

Upon the main piers are anchored the main towers, which rise 143 ft. 2 in. above pier top elevation to the centerline of the main cables. The main tower columns are 36 ft. center-to-center. The pin-connected cantilever wind trusses have a total spread from center-to-center of wind cable of 190 ft. The rest tower has a height of 40 ft. 2 in. from the top of the pier to the centerline of the main cables, a spread of 22 ft. center-to-center of its columns at the base and 6 ft. at the top.

Each main cable consists of seven 1⅛-in. diameter galvanized bridge strands, each 3659 ft. 8-7/32 in. long served together with No. 10 galvanized wire on 1-in. pitch, whereas each wind cable consists of one 2¼-in. diameter high strength galvanized bridge rope 3643 ft. 11-5/16 in. long.



Pipe sections 40 ft. in length were hoisted to this platform where they were welded and shoved out through the pipe cradles of the bridge

ON THE
CONTROL OF FLOWING WELLS

. 2 | 1943 | DALLAS, TEXAS

EW DESIGN CREATED TER MONTHS OF EXPERI-ENTAL FIELD TESTING

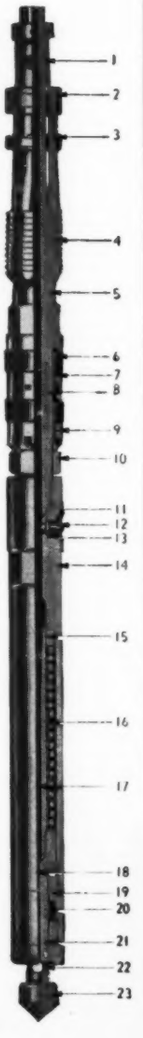
e New Type F Combination Bottom Hole Choke Automatic Safety Valve was not created over-ght—nor was it the result of a sudden inspira-n. On the contrary, many months of actual field ing with tools of various designs and construc-ns were required before the design was devel-ed that would give the desired performance. wever, each test of these various experimental igns revealed helpful data and information that entually lead to the construction of the new tool. ithout these extensive preliminary tests, the new nstruction probably would never have been und. Now, after having closely observed for eight nths the results of several of these new Type F lves installed in high pressure wells with severe nsive flow action, Otis is very much pleased with ir performance and has given them its stamp of proval.

TYPE F DESIGNED TO EET SPECIFIC NEEDS

vents Freezing of Flow Lines d at Same Time Safeguards ell Against Uncontrolled Flow

e purpose of this new tool is to ovide a Removable Bottom Hole oke to which is added a Safety lve which completely closes off w through the tubing whenever e pressure differential across the ecial Bottom Hole Choke Bean ceeds a predetermined amount. e pressure differential at which e valve operates can be adjusted er such a wide range that this w tool can be used very effec-ely as a Tubing Safety Valve ly, or as a combination Bottom le Choke and Tubing Safety lve.

As in the case of the Regular Bot-m Hole Choke, this new combi-ation tool reduces the flowing essure at a depth where the tem-erature of the gas is sufficiently gh to permit the temperature loss e to gas expansion without caus-g freezing in the flow stream.



PARTS LIST

1. Slip Carrier
2. Slip Carrier Band
3. Mandrel Band
4. Slips
5. Mandrel
6. Otis Sealing Cups
7. Upper Sealing Cup Ring
8. Cup Ring Packing
9. Lower Sealing Cup Ring
10. Cup Nut
11. Equalizing Orifice Plate
12. Equalizing Valve
13. Equalizing Valve Spring
14. Valve Cage
15. Adjusting Ring
16. Safety Valve Spring
17. Bean Extension
18. Bean
19. Packing Housing
20. Chevron Packing
21. Valve Seat
22. Intake Ports
23. Valve

NEW TYPE F SAFETY VALVE SERVES DUAL PURPOSE...

A positive, automatic Sub-Surface Tubing Safety Valve and Bottom Hole Choke . . . that's the New OTIS Type F Safety Valve. Serving a dual purpose, it is positive, yet no more complicated than any ordinary piston assembly.

It is essentially a spring loaded piston, through which an orifice is drilled to serve as a flow bean. On the lower end of the piston and extending below the body of the tool is the valve. Flow enters the flow bean through four horizontal ports in the piston, situated just above the valve. (Fig. 1) The entire flow is directed through the bean by pressure-seal packing within the housing.

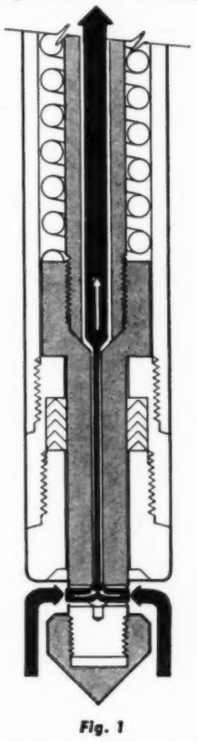


Fig. 1

The piston is held open by compression in the spring which forces the piston down against the upward force of the flowing differential pressure. The instant this pressure differential exceeds the amount for which the spring was adjusted, the piston moves up, the valve engaging the seat and shutting off all flow through the tubing.

The tool is operated entirely by pressure differential and is not dependent upon flow velocities.

Fig. 2

This feature completely eliminates the sensitiveness and inconsistencies that frequently cause trouble with velocity type valves.

The Type F Safety Valve has been used primarily in gas wells, condensate wells and wells with high gas/oil ratios to prevent freezing in flow lines, and at the same time to provide protection against uncontrolled tubing flow. The practice is to introduce sufficient compression into the coiled spring to hold the piston in its open position so long as the well is producing against the pressure maintained on the surface gathering system, but to close instantly should the surface pressure drop below a predetermined level. This provides an automatic Sub-Surface shutoff in the event surface connections fail or are damaged from any cause.

NEW CONSTRUCTION PREVENTS FLOW-CUTTING

Resistance to abrasion, most important feature

The abrasive action of the flow stream was one of the most important considerations in the basic design of the Type F Valve. The cutting action of the flow stream entering the valve is greatly reduced by placing the four horizontal ports at 90 deg. angles. This causes the flow entering each port to deflect upwardly against the flow from the opposite port, thus cushioning the change of direction and greatly reducing cutting at this point. (Fig. 2.)

The construction of the new valve is such that both the valve and valve seat are placed out of the direct line of flow beneath the bean where the flow velocities are relatively slow. The flow course above the bean is one straight bore through the valve and mandrel assembly—streamlined with no baffles or projections to be cut out or to impede flow. (Fig. 1.)

The Type F Safety Valve is set at a depth where the temperature of the flow stream is sufficiently high to absorb the temperature loss due to the pressure drop without causing freezing in the flow stream.

Like all other Otis Sub-Surface Controls, the Type F Safety Valve is run and pulled under pressure on a steel measuring line.

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS

Traveling trams used in constructing the bridge

Upon the completion of the cable erection, the pipe was erected by placing the various lengths of pipe on welding platforms constructed adjacent to each main pier and at the proper elevation. Bell-hole welds were made at each joint and then the pipe was moved out on the bridge by shoving two ways from the pier on the low side and one way from the pier on the high side. The final welds were made at the center of the main span, adjacent to the pier on the low side, and at each end of the bridge. Upon completing the erection and welding of the pipe, a 988 lb. per sq. in. hydrostatic test was made after which the pipe on the bridge was connected into the main line previously completed and tested.

As this bridge is relatively close to the Naval Aviation Training Base, it was necessary to place flashing electric beacons and obstruction lights on the main towers as well as obstruction lights on the main cables. The towers and pipe were painted orange and white in alternating bands to conform with all government regulations and requirements.

North Canadian Bridge

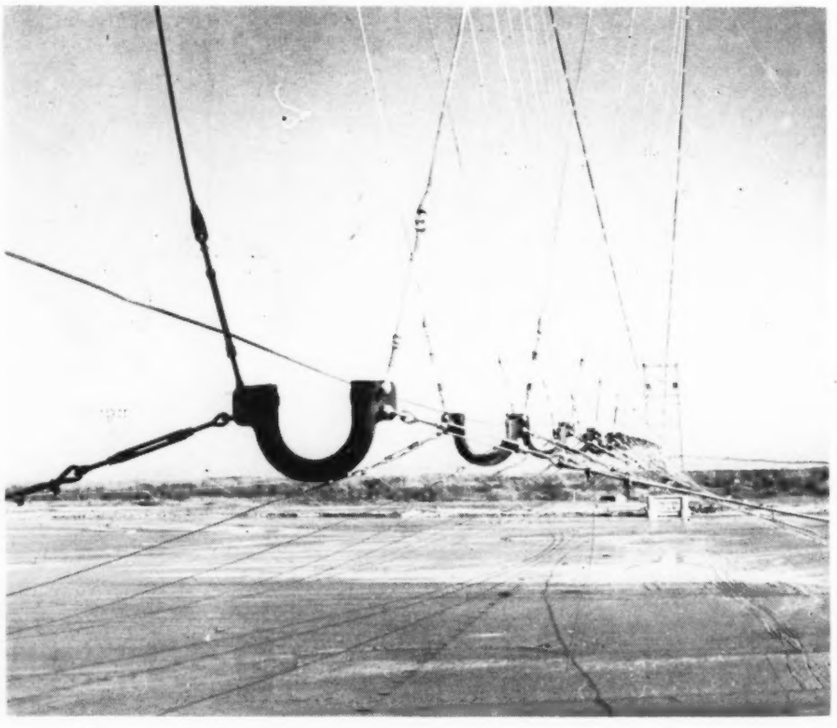
The North Canadian River bridge has a clear span of 360 ft. employing one single main cable and two wind cables. The two main piers are of concrete caisson construction carried to a maximum depth of 34 ft. 6 in. and are founded on steel H-piling. Both concrete anchorages are also founded on steel H-piling. The pipe for the bridge was welded into a single length on the ground, raised in place complete with the pipe cradles, by simultaneously picking up at five equidistant points. Next the suspenders were connected to the cradles, then the pipe was tested, using the same method as employed in the case of the South Canadian River bridge.

All structural steel for both bridges was fabricated entirely from stock at the contractor's fabricating plant at Des Moines, Iowa, and all cables were supplied by John A. Roebling's Sons Company, Trenton, New Jersey.

The construction of these bridges was under the direction of the writer of this article with the following field personnel: Griffith E. Brogan, project construction engineer; L. H. Heidbreder, general superintendent, and Hobson Pearce, superintendent of construction of the substructure of the North Canadian bridge. The owners were represented in the field by A. A. Phillips for a few weeks before he was called to the army, then by Don Boydston who assumed the duties of field engineer and inspector and served in this capacity until both structures were completed.

The writer wishes to express his appreciation of the exceptional coöperation received from the owners, engineers, field engineers, fabricating shops, and construction men during the construction of this project, as by their never-ceasing efforts, all obstacles, such as bad weather, difficulties in obtaining materials and labor were finally overcome, and the project, which might have been a most trying ordeal, turned out to be a pleasant undertaking.

☆ ☆ ☆



A group of pipe cradles showing their attachments to the main and wind guy suspenders

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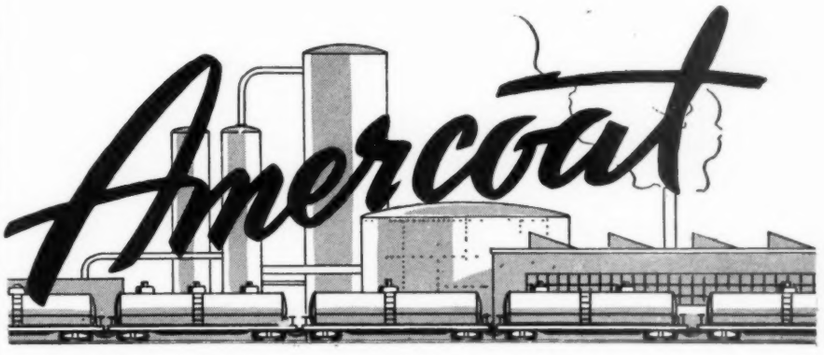

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Running Tour

WITH MEN IN THE INDUSTRY

W. F. KNODE, consulting petroleum engineer, has announced the removal of of his office to 909 Fort Worth National Bank Building, Fort Worth, Texas.

FRANK E. HANGS, who was an engineer with The Texas Pipe Line Company, Houston, Texas, is now a major in the United States Army and is stationed at Lubbock, Texas, as assistant professor of military science and tactics at Texas Technological College. He has been on active duty since November, 1940, his first assignment being to the Engineer School, Ft. Belvoir, Virginia, as a captain. He remained there a year and was then assigned to Texas Tech. Last summer he was made a major.

W. H. BALKA, president, has announced the organization of the General Engineering Company, to operate as consulting mechanical and petroleum engineers. Offices of the company are 1110 Cotton Exchange Building, Dallas, Texas.

ALEC M. CROWELL, director, Arkansas Oil and Gas Commission, announces that the statewide hearing before the commission, originally scheduled for March 18, has been postponed, the tentative date now being March 25.

ORVILLE L. ADAMS, SR., formerly an engineer with the Guiberson Diesel Engine Company, Dallas, Texas, and now a first lieutenant in the U. S. Naval Reserve, is attached to the staff of the commander of the Alaskan Sector. His work is that of Diesel engine specialist under supervision of the base repair officer.

E. P. TALLANT has been appointed chief production engineer of the Union Oil Company of California, Los Angeles, it is announced by RONALD D. GIBBS, manager of field operations. Tallant, who joined Union Oil in 1917, replaces HOWARD C. PYLE, called to military service. Pyle is now a captain in the U. S. Army Engineering Corps.

A. G. MELVILLE, who has been engaged in mining in Arizona for the last two years, has re-entered the oil industry as a consulting geologist with offices at 1114 Second Street, Manhattan Beach, California.

JOE A. LAIRD, formerly district engineer for the Texas Railroad Commission's Gulf Coast District in Houston, Texas, is now with GEORGE W. STRAKE, Houston independent operator, as petroleum engineer. Laird, who assumed his new duties February 22 in Strake's Conroe office, is a graduate of Texas A. and M. College.

DR. GEORGE R. GRAY has resigned his position as senior research engineer, Production Research Department, Humble Oil and Refining Company, to

GEORGE R. GRAY

take charge of research and control work in the Houston laboratory, Baroid Sales Division, National Lead Company. Dr. Gray is chairman of the Southeastern Texas Section, American Chemical Society.

JOHN M. DAVIES, in the research division of The B. F. Goodrich Company since 1926, has been named director of physical research, it is announced by DR. H. E. FRITZ, company research director.

L. F. MCCOLLUM has resigned as president of The Carter Oil Company, Tulsa, Oklahoma, to become executive vice-president of the foreign producing companies of the Standard Oil Company of New Jersey. He became president of Carter May 1, 1941.

O. C. SCHORP, executive vice-president, is the new president of The Carter Oil Company. JOHN W. BRICE, vice-president in charge of exploration and research, succeeds Schorp as executive vice-president.

B. I. GRAVES, vice-president of Tide Water Associated Oil Company, has announced the appointment of HERBERT S. CHASE as manager of manufacturing of the company's Eastern Division, with headquarters in New York City. Chase, a graduate of Harvard University, has been with Tide Water Associated since 1922. He has had a wide experience in petroleum refining and prior to his new appointment was general superintendent of the company's refinery at Bayonne, New Jersey. The post of manager of manufacturing of the company's Eastern Division was formerly held by the late CHARLES R. BARTON.

Graves also announced the appointment of GEORGE C. CAINE as superintendent of the Bayonne Refinery, succeeding Chase. A graduate of Massachusetts Institute of Technology, Caine joined Tide Water Associated's refinery staff of 1926 as a member of the Research and Development Department. Since 1938 he has occupied the position of assistant general superintendent of the Bayonne refinery.

W. A. SCHLUETER, head of the Refinery Supply Company, Tulsa, Oklahoma, was a recent business visitor in Dallas, Texas.

FRANK E. RICHARDSON, manager of the Pan American Pipe Line Company, and assistant manager of the Pan American Production Company and the Pan American Gas Company, Houston, Texas, has been given a leave of absence to serve in an engineering capacity with War Emergency Pipelines, Inc., on the construction of the 20-in. products line from the Gulf Coast area to Seymour, Indiana. E. V. HEWITT, general superintendent of Pan American Production Company, will act as assistant to E. R. TURNER, vice-president of the Pan American companies, and supervise their operation.

JOHN A. FALKNER, who has been superintendent for the M. W. Turner Company, has resigned and accepted a post as engineer for Gulf Oil Corporation, making his headquarters at Seminole, Oklahoma.

ENSIGN ROBERT D. FITTING, formerly employed by the Goldsmith Pool Engineering Committee, and who has many friends in West Texas, recently graduated from the Navy School of Indoctrination at Tucson, Arizona, in the upper grade brackets. At present he is assigned to temporary duties in the Navy Training School at Norman, Oklahoma, where he is the athletic director.

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LAUGH WITH BARNEY

Molly: I wrote a confession story once.

Polly: Was it bought?

Molly: No. But the editor came all the way from New York to California to see me.

* * *

"How do you feel about Margie?"

"Cautiously and with tact, old fellow, because she's liable to sock you."

* * *

Gob: What keeps your shoulder strap up?

Gal: Only your extreme timidity?

* * *

"I suppose you and your wife have a joint checking account."

"No. This is my second wife."

* * *

Mandy, sixty years old but looking much younger, was asked the secret of hiding her years. She said, "When ah works, ah works hard; when ah sits, ah sits loose; an' when ah starts worryin', ah jes goes to sleep."

* * *

Guide: We are now passing the oldest rum house in Louisiana.

Voice from the Rear: Why?

* * *

Definition

Goilmick. Not a gremlin—a Goilmick is supposed to be an evil or mischievous spirit, aerobic in nature, parading in little Uncle Sam suits scattering tape and involving the industry in helpless entanglements, aerating government offices working on oil problems, with peculiar propensities for anticipating and frustrating needed effort for the oil industry.

* * *

Friend: And what did you think when you looked into the barrel of the holdup man's pistol?

Robbery Victim: "I thought to myself, 'That's the first tunnel I ever saw that had a handle on it.' "

* * *

"That worker seems frantic. What's the matter?"

"Oh, the poor fellow is deaf and dumb and he just hit his thumb with a hammer and can't find a pad and pencil."

* * *

She was a good-looking blonde, and when her tire went flat she hailed a passing motorist. He stopped:

"Wonder if you'd help a girl in trouble?" she inquired.

He said, "Sure, sister, what kind of trouble do you want to get into?"

Father (speaking angrily to unruly son): Young man, it's a mighty good thing I'm not a rich man. You'd be very sorry.

Son: Why, dad?

Father: Because, by heck, I'd disinherit you!

* * *

Mother: I don't think the man upstairs likes Johnnie to play on his drum.

Father: What makes you think so?

Mother: Well, this afternoon he gave Johnnie a knife and asked him if he knew what was inside the drum.

* * *

Father: The man who marries my daughter will get a prize.

Young Man: May I see it, please?

* * *

She: You wouldn't dare do this if I were a man.

He: Sister, if you were a man, I wouldn't want to.

* * *

One of the gals out in the field says we don't know anything about crowded living conditions if we haven't noticed her last year's slacks.

* * *

The Wolf

If she throws her little "quivver"
In the front seat of your flivver
And says, "It's pleasant on the river"
Brother, she's a wolf.
If the get-up that she's wearin'
Turns your head and keeps you starin'
'Cause the length's a little darin',
Brother, she's a wolf.
If she's careless 'nuf to be
Sure to show a little knee
When there's plenty else to see,
Brothern she's a wolf.
If she really is bewitchin'
If she kisses with a twitchin'
As if her rosy lips were itchin'
Brother's she's a wolf.
If she really lets you pet 'er
Let's you snuggle in her sweater
And you really think you better—
Brother, BE a wolf!

* * *

Rationing

Our forefathers did without sugar till the 13th century; coal fires till the 14th; buttered bread till the 15th; potatoes or tobacco till the 16th; coffee, tea or soap till the 17th; pudding till the 18th; gas, matches, or electricity till the 19th; canned goods till the 20th; and we have only had automobiles for a few years. Now what was it you were complaining about?

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A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 69

A VALUABLE and regular feature of *The Petroleum Engineer,* begun six years ago, the Continuous Tables were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

To readers of *The Petroleum Engineer,* who are only now becoming interested in the Continuous Tables, it should be pointed out that each table is assigned a filing or index number that conforms with the Dewey Decimal System of classification as modified and extended for the petroleum and related industries by L. C. Uren, professor of Petroleum Engineering at the University of California. This complete index has been published in earlier installments of the tables and is now available in booklet form at a cost of 50 cents per copy from *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas. Complete sets of the tables from the first installment to the present are also available in conjunction with subscriptions.

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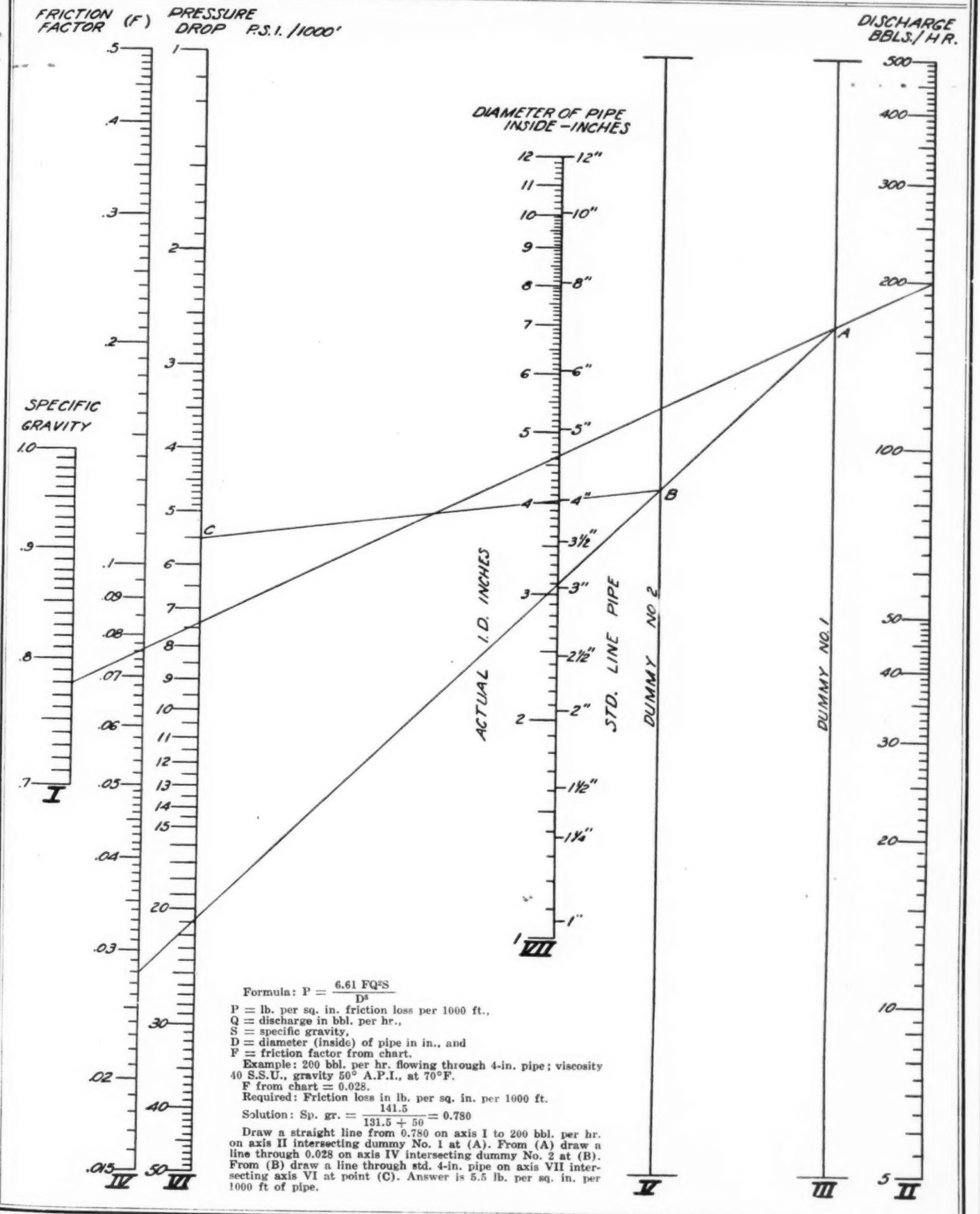
SOLUTION OF FORMULA $P = \frac{6.61\,FQ^2S}{D^5}$ FOR CRUDE OIL FLOW IN PIPE LINES



Formula: $P = \frac{6.61\,FQ^2S}{D^5}$

P = lb. per sq. in. friction loss per 1000 ft.,
Q = discharge in bbl. per hr.,
S = specific gravity,
D = diameter (inside) of pipe in in., and
F = friction factor from chart.

Example: 200 bbl. per hr. flowing through 4-in. pipe; viscosity 40 S.S.U., gravity 50° A.P.I., at 70°F.

F from chart = 0.028.

Required: Friction loss in lb. per sq. in. per 1000 ft.

Solution: Sp. gr. $= \frac{141.5}{131.5 + 50} = 0.780$

Draw a straight line from 0.780 on axis I to 200 bbl. per hr. on axis II intersecting dummy No. 1 at (A). From (A) draw a line through 0.028 on axis IV intersecting dummy No. 2 at (B). From (B) draw a line through std. 4-in. pipe on axis VII intersecting axis VI at point (C). Answer is 5.5 lb. per sq. in. per 1000 ft of pipe.

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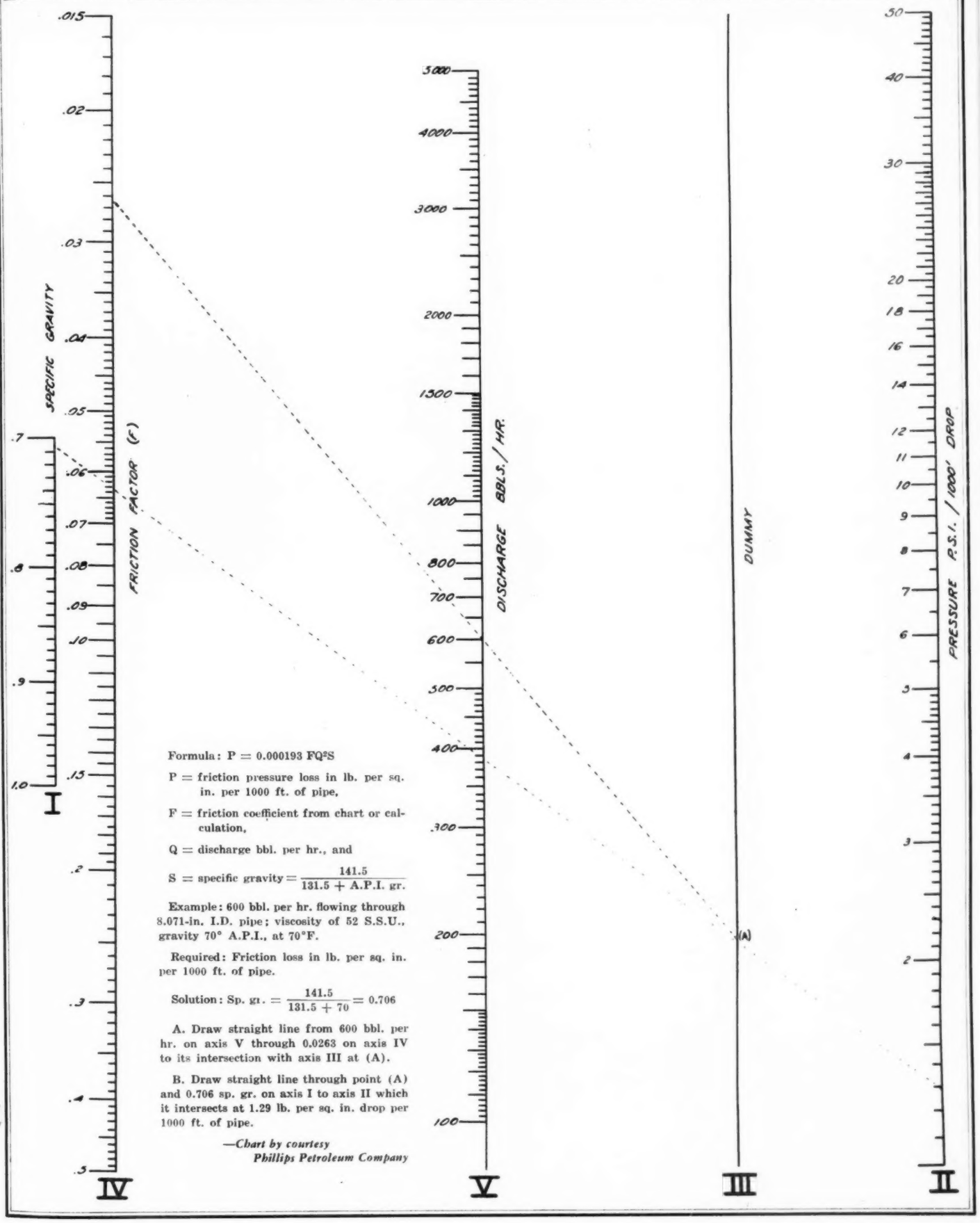
SOLUTION OF FORMULA $P = 0.000193\ FQ^2S$ FOR OIL FLOW IN 8-IN. STD. PIPE



Formula: $P = 0.000193\ FQ^2S$

P = friction pressure loss in lb. per sq. in. per 1000 ft. of pipe,

F = friction coefficient from chart or calculation,

Q = discharge bbl. per hr., and

S = specific gravity = $\frac{141.5}{131.5 + \text{A.P.I. gr.}}$

Example: 600 bbl. per hr. flowing through 8.071-in. I.D. pipe; viscosity of 52 S.S.U., gravity 70° A.P.I., at 70°F.

Required: Friction loss in lb. per sq. in. per 1000 ft. of pipe.

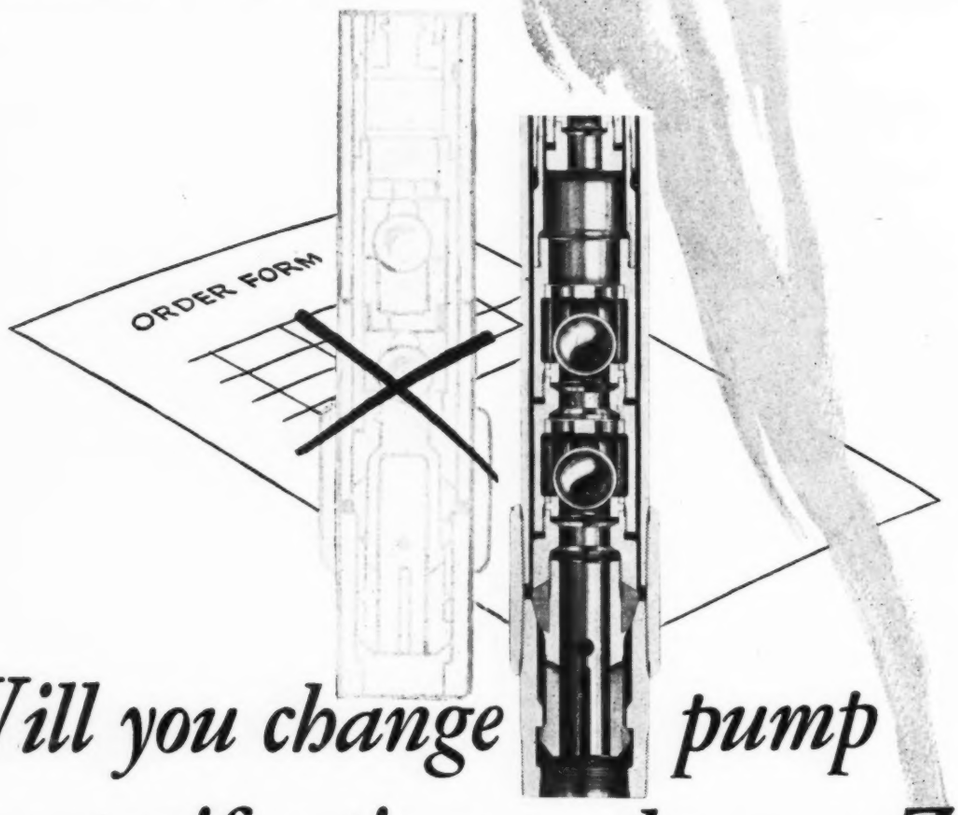
Solution: Sp. gr. = $\frac{141.5}{131.5 + 70} = 0.706$

A. Draw straight line from 600 bbl. per hr. on axis V through 0.0263 on axis IV to its intersection with axis III at (A).

B. Draw straight line through point (A) and 0.706 sp. gr. on axis I to axis II which it intersects at 1.29 lb. per sq. in. drop per 1000 ft. of pipe.

—Chart by courtesy Phillips Petroleum Company

Business is ~~as~~ un usual in the Oil Industry



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AXELSON 50TH YEAR 1892 1942 ARMY E NAVY

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3400-3495 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

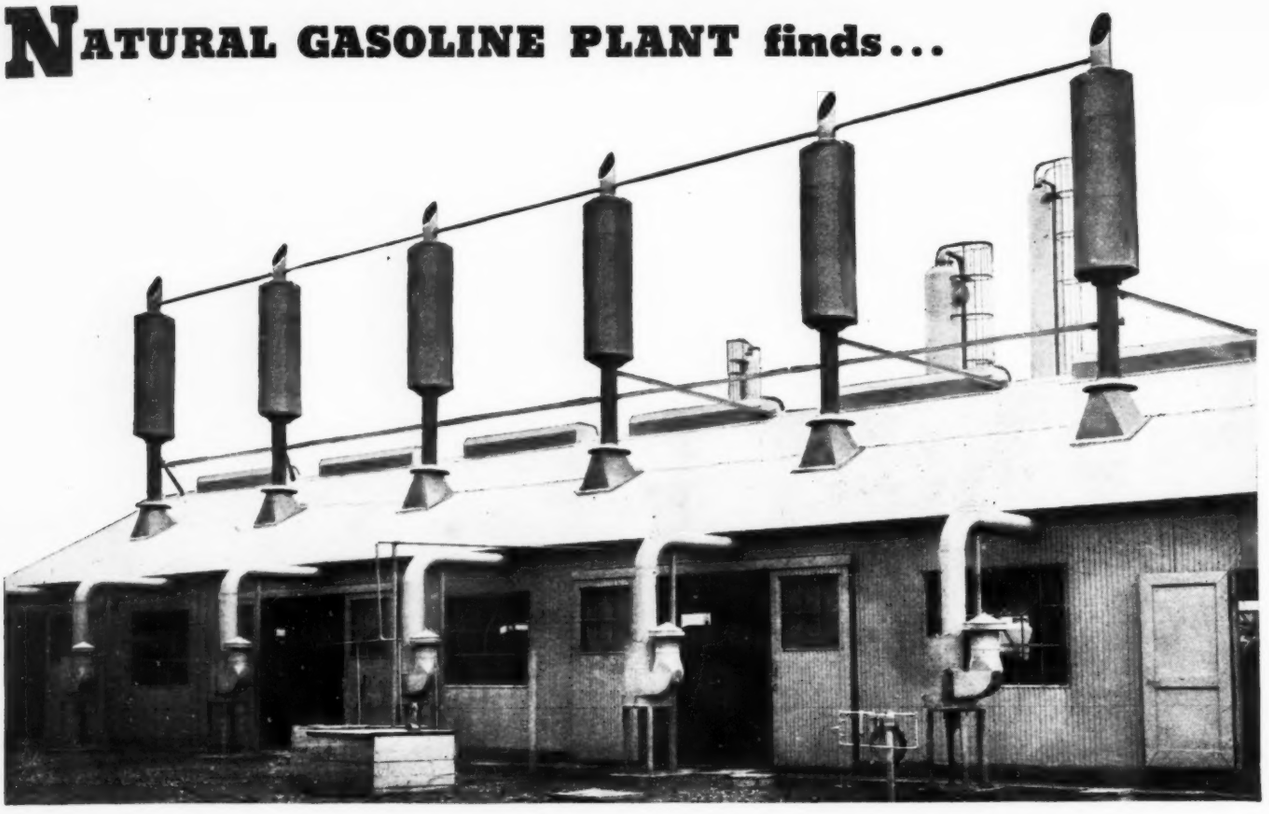
Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																				
	3400	3405	3410	3415	3420	3425	3430	3435	3440	3445	3450	3455	3460	3465	3470	3475	3480	3485	3490	3495
2	82.62	82.69	82.75	82.82	82.87	82.93	82.99	83.06	83.11	83.17	83.23	83.30	83.36	83.41	83.47	83.54	83.60	83.65	83.71	83.78
4	116.8	116.9	117.0	117.1	117.2	117.3	117.4	117.5	117.6	117.6	117.7	117.8	117.9	118.0	118.1	118.2	118.2	118.3	118.4	118.5
6	143.1	143.2	143.3	143.4	143.5	143.6	143.7	143.8	143.9	144.0	144.1	144.3	144.4	144.5	144.6	144.7	144.8	144.9	145.0	145.1
8	165.2	165.4	165.5	165.6	165.7	165.8	165.9	166.1	166.2	166.3	166.5	166.6	166.7	166.8	166.9	167.1	167.2	167.3	167.4	167.6
10	184.7	184.9	185.0	185.2	185.3	185.5	185.6	185.7	185.9	186.0	186.1	186.3	136.4	186.5	186.7	186.8	186.9	187.1	187.2	187.3
12	202.4	202.6	202.7	202.9	203.0	203.2	203.3	203.5	203.6	203.8	203.9	204.1	204.2	204.3	204.5	204.7	204.8	204.9	205.1	205.2
14	218.6	218.8	218.9	219.2	219.3	219.5	219.6	219.8	219.9	220.1	220.3	220.4	220.6	220.7	220.9	221.1	221.2	221.4	221.5	221.7
16	233.7	233.9	234.1	234.3	234.4	234.6	234.8	234.9	235.1	235.3	235.4	235.6	235.8	235.9	236.1	236.3	236.5	236.6	236.8	237.0
18	247.9	248.1	248.3	248.5	248.7	248.9	249.0	249.2	249.4	249.6	249.7	249.9	250.1	250.3	250.5	250.7	250.8	251.0	251.2	251.4
20	261.3	261.5	261.7	261.9	262.1	262.3	262.5	262.7	262.9	263.0	263.2	263.4	263.6	263.8	263.9	264.2	264.4	264.6	264.7	264.9
21	267.8	268.0	268.2	268.4	268.6	268.8	268.9	269.2	269.4	269.6	269.8	269.9	270.2	270.4	270.5	270.8	270.9	271.1	271.3	271.5
22	274.0	274.3	274.5	274.7	274.9	275.1	275.3	275.5	275.7	275.9	276.1	276.3	276.5	276.7	276.9	277.1	277.3	277.5	277.6	277.9
23	280.2	280.5	280.7	280.9	281.1	281.3	281.5	281.7	281.9	282.1	282.3	282.5	282.7	282.9	283.1	283.3	283.5	283.7	283.9	284.2
24	286.2	286.5	286.7	286.9	287.1	287.3	287.5	287.8	287.9	288.2	288.4	288.6	288.8	288.9	289.2	289.4	289.6	289.8	290.0	290.3
25	292.2	292.4	292.6	292.8	293.1	293.3	293.5	293.7	293.9	294.1	294.3	294.6	294.8	294.9	295.2	295.4	295.6	295.8	296.0	296.3
26	297.9	298.2	298.4	298.6	298.9	299.1	299.3	299.5	299.7	299.9	300.1	300.4	300.6	300.8	300.9	301.2	301.5	301.7	301.9	302.1
27	303.6	303.9	304.1	304.3	304.5	304.7	304.9	305.2	305.4	305.6	305.8	306.1	306.3	306.5	306.7	306.9	307.2	307.4	307.6	307.9
28	309.2	309.5	309.7	309.9	310.2	310.4	310.6	310.8	311.1	311.3	311.5	311.8	311.9	312.2	312.4	312.6	312.9	313.1	313.3	313.6
29	314.6	314.9	315.1	315.4	315.6	315.8	316.0	316.3	316.5	316.7	316.9	317.2	317.4	317.7	317.9	318.1	318.4	318.6	318.8	319.1
30	320.0	320.3	320.5	320.8	321.0	321.2	321.4	321.7	321.9	322.2	322.4	322.7	322.9	323.1	323.3	323.6	323.8	324.0	324.2	324.5
31	325.3	325.6	325.8	326.1	326.3	326.6	326.8	327.1	327.3	327.5	327.7	328.0	328.2	328.5	328.7	328.9	329.2	329.4	329.6	329.9
32	330.5	330.8	331.0	331.3	331.6	331.8	332.0	332.3	332.5	332.7	332.9	333.3	333.5	333.7	333.9	334.2	334.4	334.7	334.9	335.2
33	335.7	335.9	336.2	336.5	336.7	336.9	337.2	337.5	337.7	337.9	338.2	338.4	338.7	338.9	339.1	339.4	339.6	339.9	340.1	340.4
34	340.7	340.9	341.2	341.5	341.8	342.0	342.2	342.5	342.7	342.9	343.2	343.5	343.7	343.9	344.2	344.5	344.7	344.9	345.2	345.5
35	345.7	345.9	346.2	346.5	346.7	346.9	347.2	347.5	347.7	347.9	348.2	348.5	348.7	348.9	349.2	349.5	349.7	349.9	350.2	350.5
36	350.6	350.9	351.1	351.4	351.7	351.9	352.1	352.4	352.7	352.9	353.2	353.5	353.7	353.9	354.2	354.9	354.7	354.9	355.2	355.5
37	355.4	355.7	355.9	356.3	356.5	356.8	357.0	357.3	357.6	357.8	358.0	358.3	358.6	358.8	359.1	359.4	359.6	359.9	360.1	360.4
38	360.2	360.5	360.7	361.0	361.3	361.5	361.8	362.1	362.3	362.6	362.8	363.1	363.4	363.6	363.9	364.2	364.4	364.7	364.9	365.2
39	364.9	365.2	365.5	365.8	366.0	366.3	366.5	366.8	367.1	367.3	367.6	367.9	368.1	368.4	368.3	369.9	369.2	369.5	369.7	370.0
40	369.6	369.9	370.1	370.5	370.7	370.9	371.2	371.5	371.8	372.0	372.3	372.6	372.9	373.1	373.4	373.7	373.9	374.2	374.4	374.7
41	374.1	374.4	374.7	375.0	375.3	375.5	375.8	376.1	376.4	376.6	376.9	377.2	377.5	377.7	377.9	378.3	378.5	378.8	379.1	379.4
42	378.7	379.0	379.3	379.6	379.9	380.1	380.4	380.7	380.9	381.2	381.5	381.8	382.1	382.3	382.6	382.9	383.2	383.4	383.7	383.9
43	383.1	383.4	383.7	384.0	384.3	384.6	384.8	385.2	385.4	385.7	385.9	386.3	386.5	386.8	387.1	387.4	387.6	387.9	388.2	388.5
44	387.6	387.9	388.2	388.5	388.8	389.0	389.3	389.6	389.9	390.2	390.4	390.8	391.0	391.3	391.5	391.9	392.1	392.4	392.7	393.0
45	391.9	392.3	392.6	392.9	393.2	393.4	393.7	394.0	394.3	394.6	394.8	395.2	395.4	395.7	395.9	396.3	396.6	396.8	397.1	397.4
46	396.3	396.6	396.9	397.2	397.5	397.8	398.0	398.4	398.6	398.9	399.2	399.5	399.8	400.1	400.3	400.7	400.9	401.2	401.5	401.8
47	400.6	400.9	401.2	401.6	401.8	402.1	402.4	402.7	402.9	403.3	403.5	403.9	404.2	404.4	404.7	405.1	405.3	405.6	405.9	406.2
48	404.8	405.1	405.4	405.8	406.1	406.3	406.6	406.9	407.2	407.5	407.8	408.1	408.4	408.7	408.9	409.3	409.6	409.9	410.1	410.5
49	409.0	409.4	409.6	409.9	410.3	410.6	410.8	411.2	411.5	411.7	412.0	412.4	412.7	412.9	413.2	413.6	413.8	414.1	414.4	414.8
50	413.2	413.5	413.8	414.1	414.4	414.7	414.9	415.4	415.6	415.9	416.2	416.6	416.8	417.1	417.4	417.8	418.0	418.3	418.6	418.9
51	417.2	417.6	417.9	418.2	418.5	418.8	419.1	419.5	419.7	420.0	420.3	420.7	420.9	421.2	421.5	421.9	422.2	422.5	422.7	423.1
52	421.3	421.7	421.9	422.3	422.6	422.9	423.2	423.6	423.9	424.2	424.4	424.8	425.1	425.4	425.7	426.0	426.3	426.6	426.9	427.3
53	425.4	425.7	426.0	426.4	426.7	426.9	427.3	427.6	427.9	428.2	428.5	428.9	429.2	429.4	429.7	430.1	430.4	430.7	430.9	431.3
54	429.3	429.7	430.0	430.4	430.7	430.9	431.3	431.6	431.9	432.2	432.5	432.9	433.2	433.5	433.8	434.1	434.4	434.7	435.0	435.4
55	433.3	433.7	433.9	434.4	434.7	434.9	435.2	435.6	435.9	436.2	436.5	436.9	437.2	437.5	437.8	438.1	438.4	438.7	439.0	439.4
56	437.2	437.6	437.9	438.3	438.6	438.9	439.2	439.6	439.9	440.2	440.4	440.8	441.1	441.4	441.7	442.1	442.4	442.7	442.9	443.4
57	441.1	441.5	441.8	442.2	442.5	442.8	443.8	443.5	443.8	444.1	444.4	444.8	445.1	445.4	445.7	446.1	446.4	446.7	446.9	447.3
58	445.0	445.4	445.7	446.1	446.4	446.7	446.9	447.4	447.7	447.9	448.3	448.7	448.9	449.3	449.6	449.9	450.3	450.6	450.9	451.2
59	448.8	449.2	449.5	449.9	450.2	450.5	450.8	451.2	451.5	451.8	452.1	452.5	452.8	453.1	453.4	453.8	454.1	454.4	454.7	455.1
60	452.6	452.9	453.3	453.7	453.9	454.3	454.6	455.0	455.3	455.6	455.9	456.3	456.6	456.9	457.2	457.6	457.9	458.3	458.6	458.9
61	456.3	356.7	457.0	457.4	457.7	458.1	458.4	458.8	459.1	459.4	459.7	460.1	460.4	460.7	461.0	461.4	461.7	462.0	462.4	462.7
62	460.1	460.5	460.8	461.2	461.5	461.8	462.1	462.6	462.8	463.1	463.5	463.8	464.2	464.5	464.8	465.2	465.5	465.8	466.1	466.5
63	463.8	464.2	464.5	464.9	465.2	465.5	465.8	466.2	466.5	466.8	467.2	467.6	467.9	468 2	468.5	468.9	469.2	469.6	469.9	470.3
64	467.4	467.8	468.2	468.6	468.9	469.2	469.5	469.9	470.2	470.6	470.9	471.3	471.6	471.9	472.2	472.6	472.9	473.3	473.6	474.0
65	471.1	471.5	471.8	472.2	472.5	472.8	473.2	473.6	473.9	474.2	474.5	474.9	475.3	475.6	475.9	476.3	476.6	476.9	477.3	477.7
66	474.7	475.1	475.4	475.8	476.1	476.5	476.8	477.2	477.5	477.9	478.2	478.6	478.9	479.2	479.6	479.9	480.3	480.6	480.9	481.3
67	478.2	478.7	478.9	479.4	479.7	480.1	480.4	480.8	481.1	481.4	481.8	482.2	482.5	482.8	483.2	483.6	483.9	484.2	484.6	484.9
68	481.8	482.2	482.6	482.9	483.3	483.6	483.9	484.4	484.7	485.0	485.4	485.8	466.1	486.4	486.8	487.2	487.5	487.8	488.2	488.6
69	485.4	485.8	486.1	486.5	486.9	487.2	487.5	487.9	488.3	488.6	488.9	489.4	489.7	490.0	490.4	490 8	491.1	491.4	491.8	492.2
70	488.9	489.3	489.6	490.1	490.4	490.7	491.1	491.5	491.8	492.1	492.5	492.9	493.2	493.6	493.9	494.3	494.7	494.9	495.3	495.7
71	492.3	492.8	493.1	493.5	493.8	494.2	494.5	494.9	495.3	495.6	495.9	496.4	496.7	497.0	497.4	497.8	498.1	498.5	498.8	499.2
72	495.8	496.2	496.5	496.9	497.3	497.6	497.9	498.4	498.7	499.1	499.4	499.9	500.2	500.5	500.9	501.3	501.6	501.9	502.3	502.7
73	499.2	499.7	499.9	500.4	500.8	501.1	501.4	501.9	502.2	502.6	502.9	503.3	503.7	504.0	504.4	504.8	505.1	505.5	505.8	506.2
74	502.6	503.0	503.4	503.8	504.2	504.5	504.9	505.3	505.6	505.9	506.3	506.7	507.1	507.4	507.8	508.2	508.6	508.9	509.2	509.7
75	506.0	506.4	506.8	507.2	507.6	507.9	508.3	508.7	509.0	509.4	509.7	510.2	510.5	510.9	511.2	511.6	511.9	512.3	512.7	513.1
76	509.4	509.8	510.2	510.6	510.9	511.3	511.7	512.1	512.4	512.8	513.1	513.6	513.9	514.3	514.6	515.1	515.4	515.8	516.1	516.5
77	512.7	513.2	513.5	513.9	514.3	514.7	515.0	515.4	515.8	156.1	516.5	516.9	517.3	517.6	517.9	518.4	518.8	519.1	519.5	519.9
78	516.1	516.5	516.8	517.3	517.6	517.9	518.4	518.8	519.1	519.5	519.9	520.3	520.6	520.9	521.4	521.8	522.1	522.5	522.9	523.3
79	519.3	519.8	520.1	520.6	520.9	521.3	521.6	522.1	522.4	522.8	523.1	523.6	523.9	523.4	524.7	525.1	525.5	525.8	526.2	526.6
80	522.6	523.0	523.4	523.9	524.2	524.6	524.9	525.4	525.7	526.1	526.4	526.9	527.2	527.6	527.9	528.4	528.8	529.1	529.5	529.9
82	529.1	529.5	529.9	530.4	530.7	531.1	531.4	531.9	532.3	532.6	532.9	533.4	533.8	534.2	534.5	534.9	535.3	535.7	536.1	536.5
84	535.5	535.9	536.3	536.8	537.2	537.5	537.9	538.4	538.8	539.1	539.5	539.9	540.3	540.6	541.0	541.5	541.8	542.2	542.6	543.0
86	541.9	542.3	542.7	543.2	543.5	543.9	544.3	544.8	545.1	545.5	545.9	546.3	546.7	547.1	547.4	547.9	548.3	548.6	549.0	549.5
88	548.1	548.6	548.9	549.4	549.8	550.2	550.6	551.0	551.4	551.8	552.2	552.6	553.0	553.4	553.8	554.2	554.6	554.9	555.4	555.8
90	554.3	554.8	555.2	555.7	556.0	556.4	556.8	557.3	557.6	558.0	558.4	558.9	559.3	559.6	560.0	560.5	560.8	561.3	561.6	562.3
92	560.4	560.9	561.3	561.8	562.2	562.6	562.9	563.4	563.8	564.2	564.6	565.1	565.4	565.8	566.2	566.7	567.1	567.5	567.8	568.3
94	566.5	566.9	567.4	567.8	568.2	568.6	568.9	569.5	569.9	570.3	570.6	571.1	571.5	571.9	572.3	572.8	573.2	573.6	573.9	574.4
96	572.5	572.9	573.4	573.9	574.3	574.7	575.0	575.5	575.9	576.3	576.7	577.2	577.6	577.9	578.4	578.9	579.3	579.6	580.0	580.5
98	578.4	578.9	579.3	579.8	580.2	580.6	580.9	581.5	581.9	582.3	582.7	583.2	583.5	583.9	584.3	584.8	585.2	585.6	586.0	586.5
100	584.3	584.8	585.2	585.7	586.1	586.5	586.9	587.4	587.8	588.2	588.6	589.1	589.5	589.9	590.3	590.8	591.2	591.6	582.0	592.5

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings, intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

NATURAL GASOLINE PLANT finds...



. . . 6 answers to silent operation

This battery of six Maxim exhaust silencers quiets the roar of six powerful exhausts in a natural gasoline plant in Illinois.

Maxim Silencers are doing efficient jobs like this throughout the oil industry . . . with Maxim heavy duty silencers where there is danger of an explosion in the exhaust lines...with Maxim spark arrestor silencers, providing maximum safety (100% spark arresting) where the hazard of falling sparks cannot be tolerated . . . and with Maxim intake silencers that quiet compressor intake noise and eliminate harmful air borne vibration.

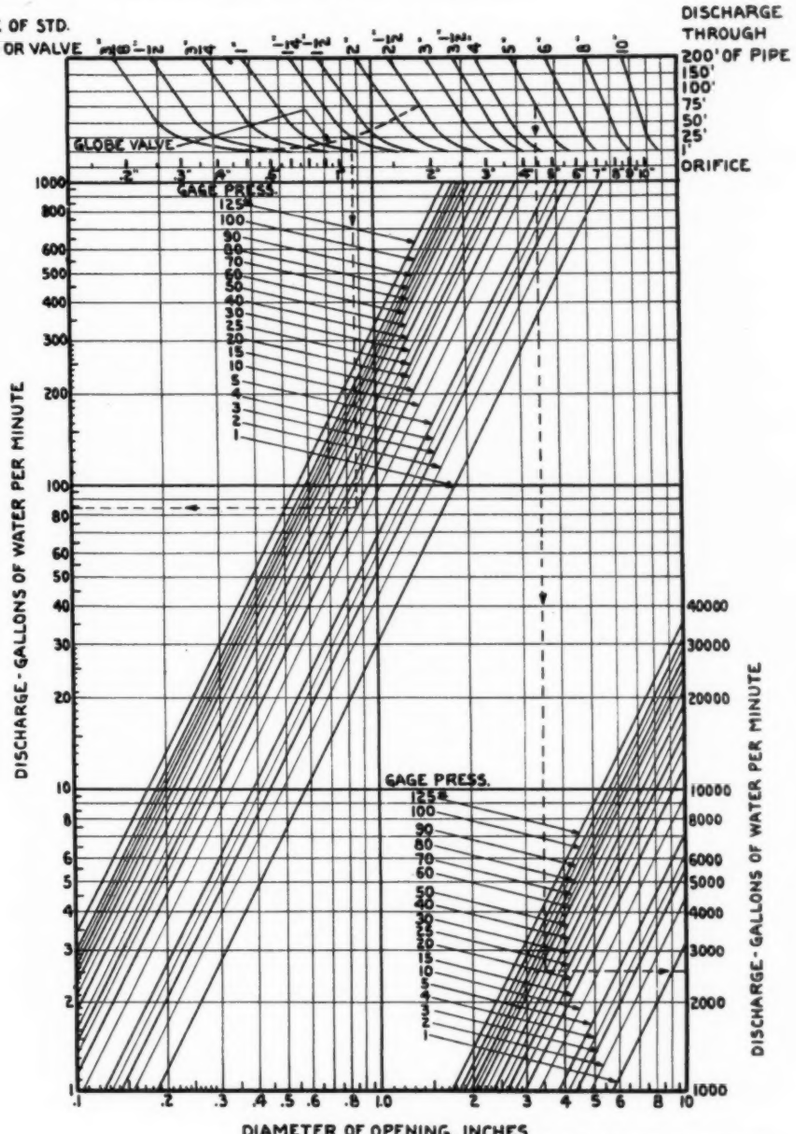
And Maxim's newest development, the Waste Heat unit, combines silencing, spark arresting (where needed) and conservation of waste exhaust heat to produce steam or hot water for heating or processing purposes. For details on these waste heat units write for Bulletins WH-100 and WH-103. The Maxim Silencer Company, 90 Homestead Avenue, Hartford, Connecticut.

MAXIM

SILENCERS and SPARK ARRESTORS

RATES OF WATER FLOW—PIPES, VALVES, AND ORIFICES

This chart is for the purpose of determining the rate of discharge of water from pipes of various lengths, globe valves, and different size orifices.



—Copyright by Crane Company.

Example: A 1¼-in. globe valve is discharging water to the atmosphere under a discharge pressure of 15 lb. per sq. in. ga. What will be the volume discharged in gal. per min.?

Solution: Enter the upper portion of the chart at the intersection of the dotted globe valve line with the line drawn for the 1¼-in. pipe or valve. Proceed downward to intersection with the diagonal for 15 lb. per sq. in. gauge pressure, and then continue horizontally to the left where the quantity discharged is given as 84 gal. per min. on the left ordinate. Note that the discharge through 25 ft. of standard 1¼-in. pipe is the same as that through the 1¼-in. globe valve.

Example: Determine the quantity of water that will be discharged through 75 ft. of 5-in. standard pipe under a discharge pressure of 50 lb. per sq. in.

Solution: Enter the upper portion of the chart at the intersection of the horizontal line for 75 ft. of pipe and the line for the 5-in. pipe size. Proceed downward to intersection with the diagonal for 50 lb. per sq. in., and then continue horizontally to the right; the quantity discharged is found to be 2600 gal. per min. on the right ordinate.

Service

... keynote for the duration

Crucial months lie ahead. More work will be demanded of your Cummins Dependable Diesels than ever before. New engines will be hard to get for reasons which you well understand. This simply means that your present Cummins Diesels must carry the load . . . *and they will carry the load providing you make service your keynote for the duration.*

This doesn't mean, however, that you will have to pamper your Cummins Diesels. They were built for tough jobs and 24-hour duty and they will give you this kind of performance indefinitely if you will observe these cardinal rules: **(1)** Keep your engines clean; **(2)** Don't tinker; **(3)** Adopt a regular schedule of preventive maintenance; **(4)** Follow the recommendations in the Operator's Instruction Manual; **(5)** When in doubt, always consult your Cummins Dealer. CUMMINS ENGINE COMPANY, Columbus, Indiana.

Illustrated at the left is the 150 hp. Model H Cummins Dependable Diesel. This engine's economy, stamina and flexibility have been proved in all types of oil field operations, drilling, pumping and generating. With the Models A, HS (supercharged) and L, it gives you a complete line of dependable power for CHEAPER FOOTAGE—*33 to 250 hp.*

MID-CONTINENT SUPPLY COMPANY • FORT WORTH, TEXAS

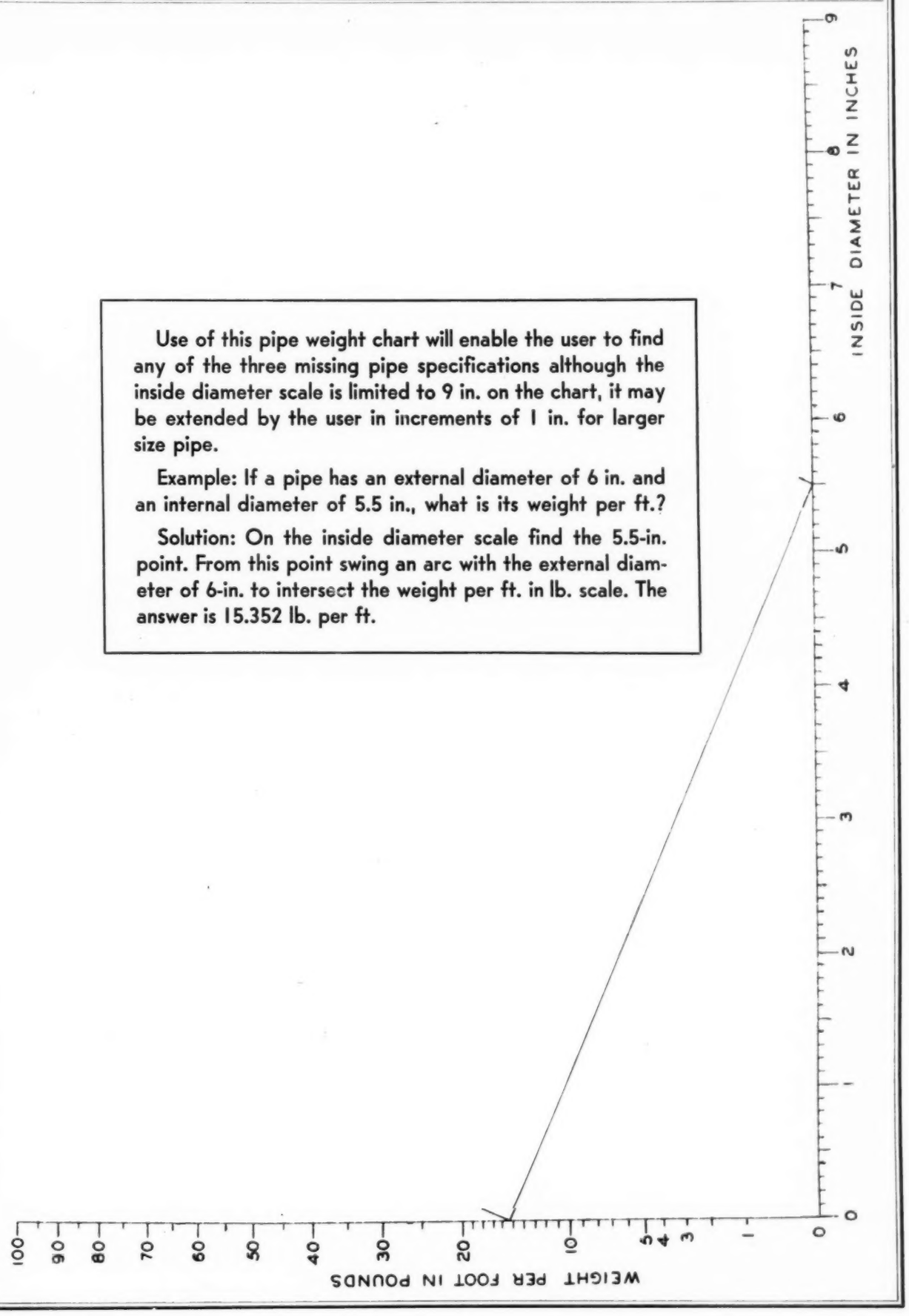
Distributors Mid-Continent Territory

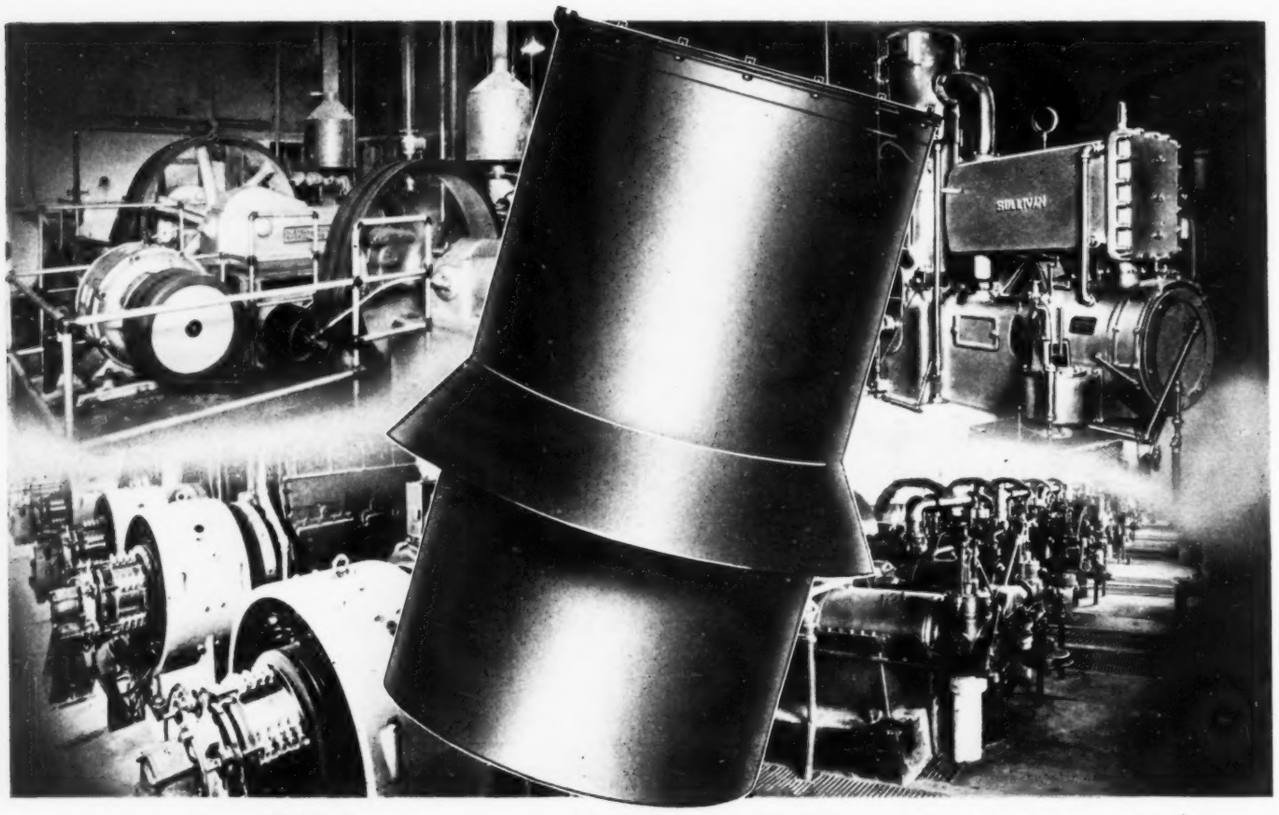
PIPE WEIGHT CHART

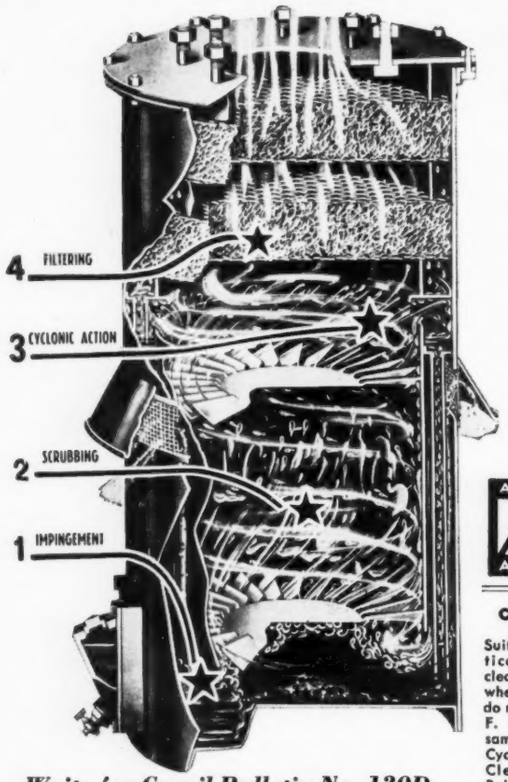
Use of this pipe weight chart will enable the user to find any of the three missing pipe specifications although the inside diameter scale is limited to 9 in. on the chart, it may be extended by the user in increments of 1 in. for larger size pipe.

Example: If a pipe has an external diameter of 6 in. and an internal diameter of 5.5 in., what is its weight per ft.?

Solution: On the inside diameter scale find the 5.5-in. point. From this point swing an arc with the external diameter of 6-in. to intersect the weight per ft. in lb. scale. The answer is 15.352 lb. per ft.







Write for Cycoil Bulletin No. 130D which gives complete information on its operation.

ASSURE YOUR POWER NEEDS FOR TOMORROW BY PROTECTING TODAY WITH CYCOIL CLEANERS

Power plants strained to capacity day after day—require every care it is possible to provide—if they are to be kept in top running condition. Cycoil air cleaner protection against destructive dust and grit means longer life and fewer interruptions for replacements and repairs.

Engine manufacturers know the Cycoil and its outstanding performance characteristics. Due to its exclusive 4-way cleaning principle, illustrated at the left, positive dust protection is assured at all times.

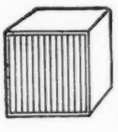
Send for facts on the Cycoil and other types of American Air Filters for every engine and compressor requirement.

AMERICAN AIR FILTERS

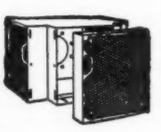
AMERICAN AIR FILTER COMPANY, INC.
INCORPORATED
384 Central Avenue, Louisville, Kentucky
In Canada: Darling Bros., Ltd., Montreal, P.Q.

CYCOIL GAS CLEANER
Suitable for practically every gas cleaning problem when temperatures do not exceed 140° F. Operates on same principle as Cycoil Oil Bath Air Cleaner. Ask for Bulletin 130D.

PL-H FILTER
is a complete assembly consisting of housing, ready to bolt to intake pipe, and dry cell type filters in which wool felt constitutes the filter medium. Ask for Bulletin 120D.



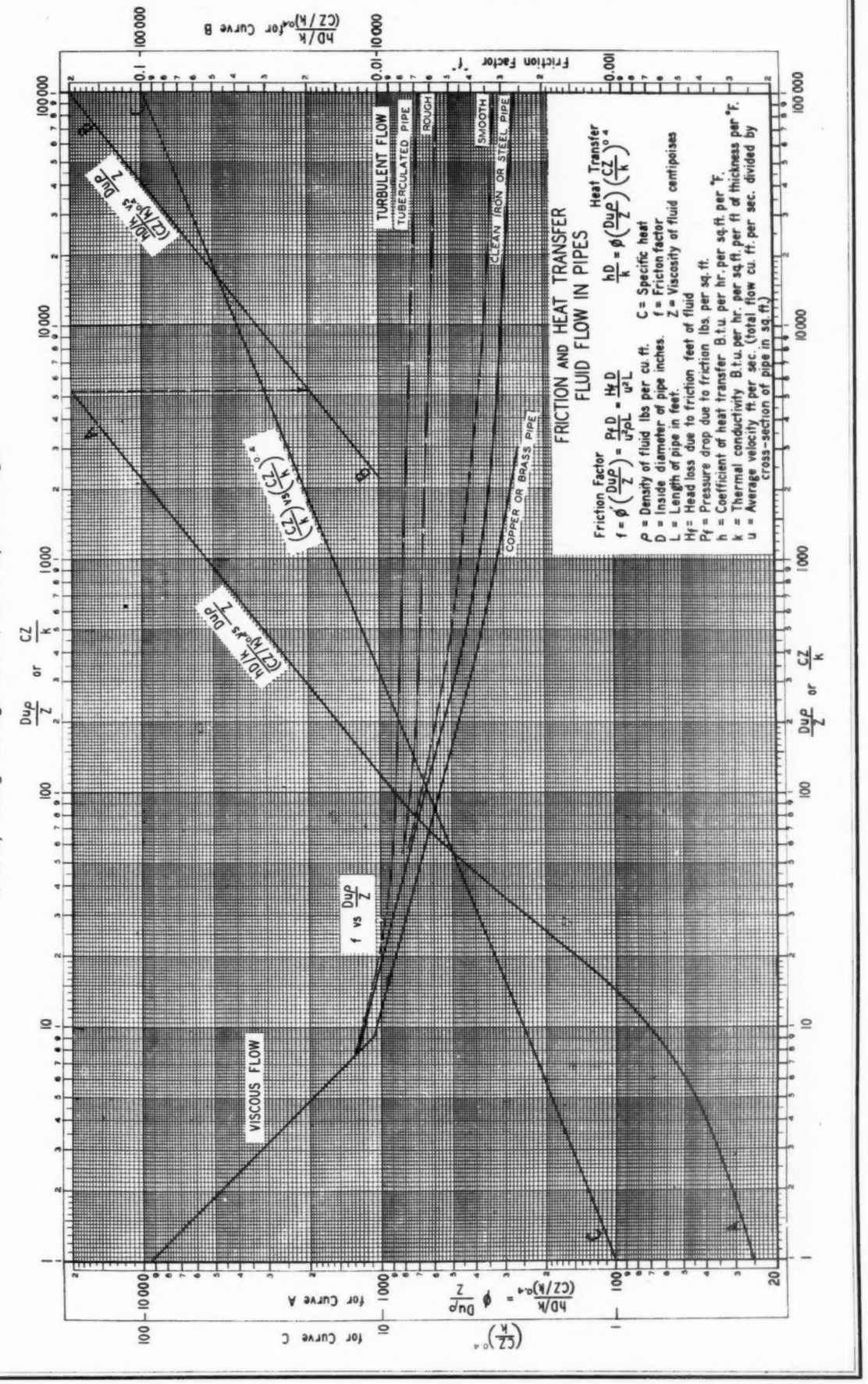
TYPE OCH FILTER
Complete assembly consisting of washable viscous impingement type filters. 1, 2, 3, or more cells are used, depending upon size of cleaning job. Ask for Bulletin 120D.



AMERICAN *Cycoil* AIR and GAS CLEANERS

FRICTION AND HEAT TRANSFER OF FLUID FLOW IN PIPES

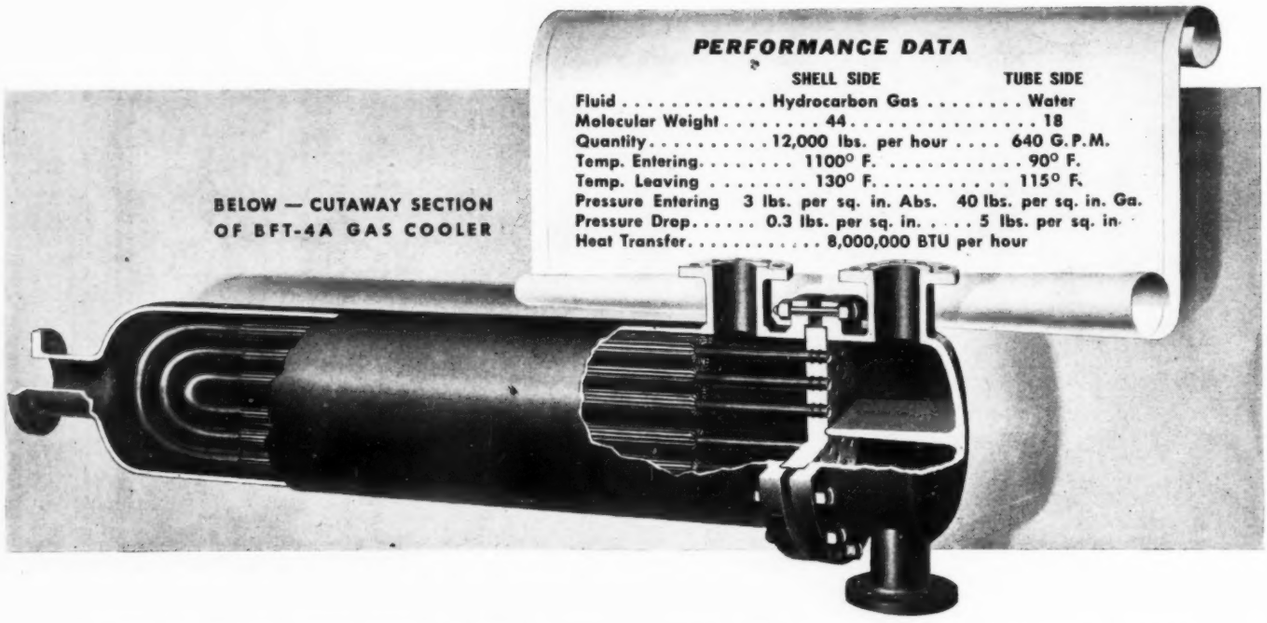
—Chart by George Granger Brown, University of Michigan


FRICTION AND HEAT TRANSFER
FLUID FLOW IN PIPES
Friction Factor
$f = \phi'\left(\frac{DuP}{Z}\right) = \frac{P_f D}{u^2 \rho L} = \frac{H_f D}{u^2 L}$
Heat Transfer
$\frac{hD}{k} = \phi\left(\frac{DuP}{Z}\right)\left(\frac{CZ}{k}\right)^{0.4}$
ρ = Density of fluid lbs per cu ft.
D = Inside diameter of pipe inches.
L = Length of pipe in feet.
Hf = Head loss due to friction feet of fluid
Pf = Pressure drop due to friction lbs per sq. ft.
h = Coefficient of heat transfer B.t.u. per hr. per sq.ft. per °F.
k = Thermal conductivity B.t.u. per hr. per sq.ft. per ft of thickness per °F.
u = Average velocity ft per sec. (total flow cu. ft. per sec. divided by cross-section of pipe in sq. ft.)
C = Specific heat
f = Fricton factor
Z = Viscosity of fluid centipoises
TURBULENT FLOW
TUBERCULATED PIPE
ROUGH
SMOOTH
CLEAN IRON OR STEEL PIPE
COPPER OR BRASS PIPE
VISCOUS FLOW
f vs DuP/Z
Friction Factor f
for Curve A
for Curve B
for Curve C
DuP/Z or CZ/k

YOU TOO CAN GET MUCH INCREASED EFFICIENCY WITH

BROWN FINTUBE HEAT EXCHANGERS

29" ID x 16' Overall Type BFT-4A Gas Cooler — in High Vacuum Service—Provides 3600 sq. ft. of Effective Surface—Transfers 8,000,000 BTU per Hour


PERFORMANCE DATA
SHELL SIDE
TUBE SIDE
Fluid . . . . . Hydrocarbon Gas . . . . . Water
Molecular Weight 44 18
Quantity . . . . . 12,000 lbs. per hour . . . . 640 G.P.M.
Temp. Entering . . . . . 1100° F. . . . . 90° F.
Temp. Leaving . . . . . 130° F. . . . . 115° F.
Pressure Entering 3 lbs. per sq. in. Abs. 40 lbs. per sq. in. Ga.
Pressure Drop . . . . . 0.3 lbs. per sq. in. . . . . 5 lbs. per sq. in.
Heat Transfer . . . . . 8,000,000 BTU per hour

BELOW — CUTAWAY SECTION OF BFT-4A GAS COOLER

Because Brown integrally bonded Fintubes, having the desired number and depth of fins, are used in effecting the heat transfer,—the primary and secondary tube surfaces of Brown Fintube Heat Exchangers can be proportioned to the transfer co-efficients of the materials being heated or cooled. This avoids the necessity of using hundreds, sometimes thousands of feet of bare tubing to satisfy the requirements of the commodity having the lower heat transfer co-efficient . . . It permits a fewer number or shorter Brown Fintubes to be used in a given heat transfer service than if plain bare tubes were used . . . And results in smaller shells, less pressure drop, less back pressure, and many other important savings in manufacturing, shipping, installation and maintenance costs.

For instance, the cooler described above, which required about 1900 lineal feet of fintube, would have required more than 11,000 lineal feet of plain bare tubing—a saving of more than 6700 lbs. of steel just in the tubing alone.

Brown Integrally Bonded Fintubes are used in all Brown Fintube Heat Exchangers—in exchangers made by most other manufacturers—and are available in a wide variety of sizes, and in mild carbon or special steels, for practically any heating or cooling requirement.

Six standard and many special types of Brown Fintube Heat Exchangers meet any requirement for effecting transfers between liquids and gases, or other commodities having unequal transfer co-efficients. Engineering assistance, recommendations, estimates, and descriptive literature furnished gladly. Let us quote on your requirements.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

CHARTS FOR COOLING TOWER REQUIREMENTS

The size of a cooling tower required to handle a given heat load varies greatly with the performance required, and care should be used in specifying the wet bulb temperature, the final approach of the tower water to the wet bulb temperature, the wind velocity, and the quantity and temperature range of the tower water being circulated.

If plant operation requires the maintenance of a definite minimum temperature it is essential that the highest prevailing wet bulb temperature, usually occurring during July, August and the early part of September, be used in rating the tower. Then, when the wet bulb temperature drops and colder tower water is obtained, the quantity of cooling water being circulated may be decreased.

Approach of the final tower water to the wet bulb temperature should be made as large as possible to avoid unnecessarily increasing the tower size. Fig. 1 illustrates the above point by showing the relation between tower size and approach to the wet bulb temperature while circulating a constant quantity of water through a given temperature range. In specifying the operating conditions an approach of not less than five degrees and preferably ten degrees or greater is recommended.

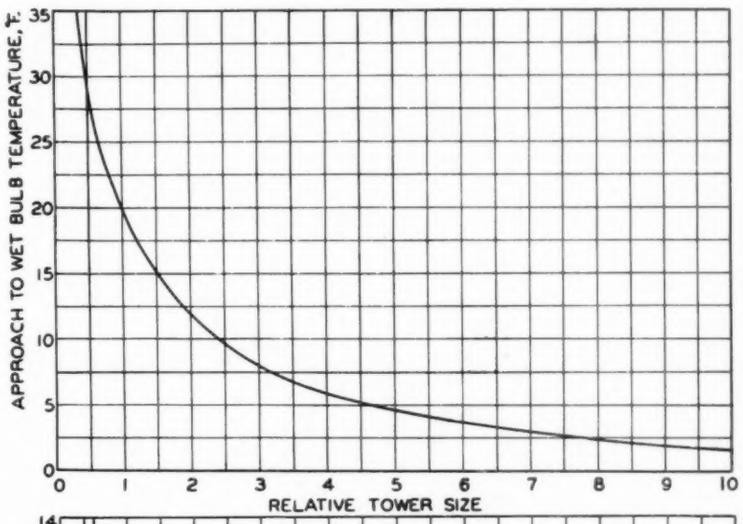
The relative size of a tower varies with the wind velocity as shown in Fig. 2. In order to obtain the required minimum temperature during the summer months, care should be taken to specify a wind velocity which is representative of the poorest conditions experienced during the warmer months rather than a figure which represents the average wind velocity over a period of years.

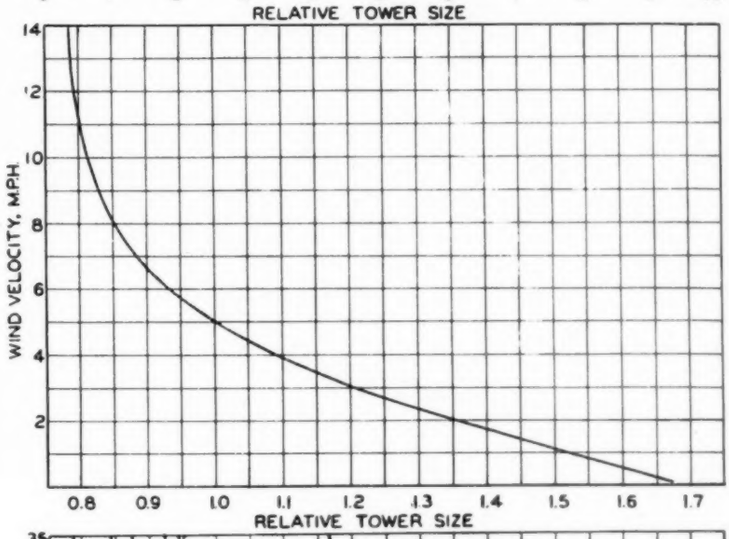
Selection of the proper circulation and temperature range of the tower water is often more or less definitely determined by process requirements. Since tower prices are proportional to their respective sizes the smallest tower capable of handling the heat load is the most economical one to use.

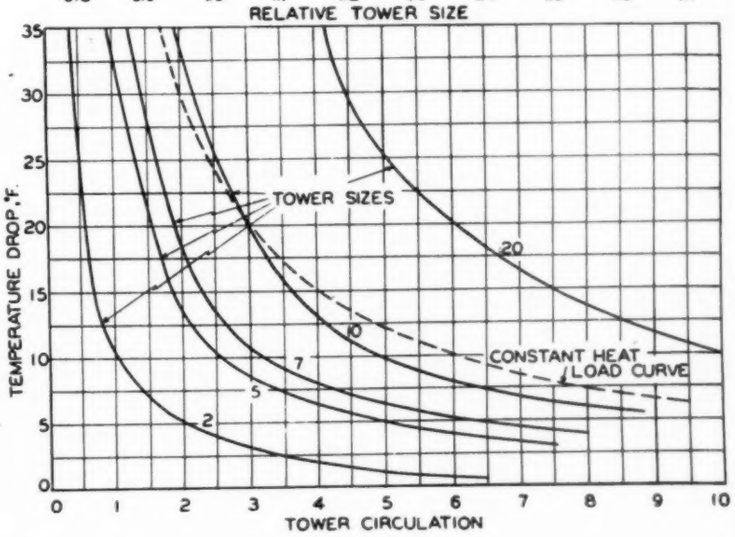
Fig. 3 further illustrates the relation between capacity, range and tower size. In general, because of the larger cooling potential, it may be concluded that for the same heat load, less tower is required for cooling a small quantity of water through a large temperature range than is required for cooling a large quantity of water through a small temperature range.

Note: Engineering data and the examples below are approximate only and the sizes of the towers determined should not be regarded as recommendations.

—Charts and data supplied by The Fluor Corporation, Ltd.

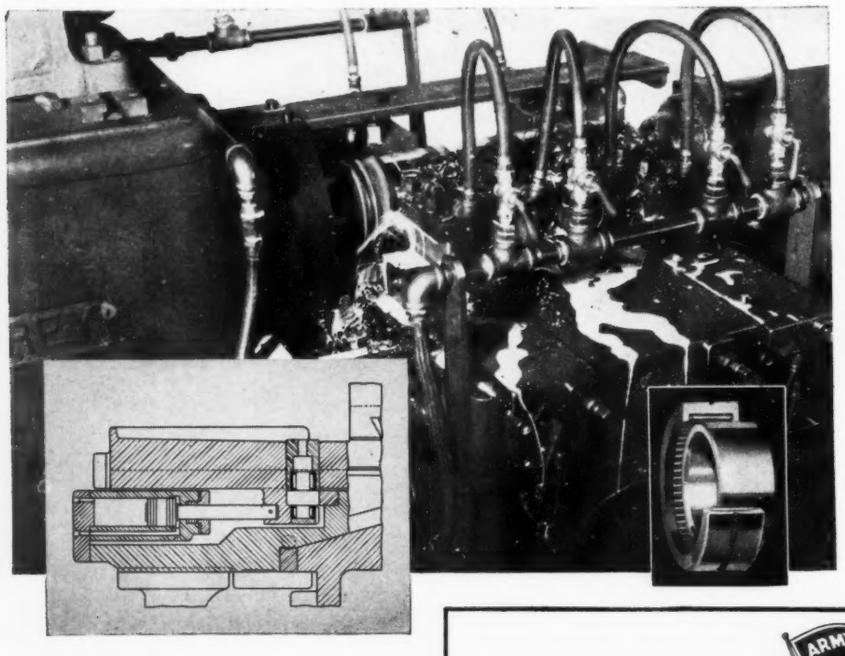




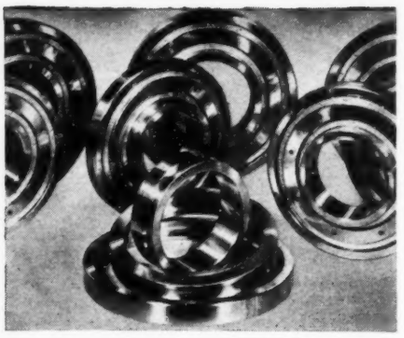


IN THE NEWS
WITH BANTAM BEARINGS

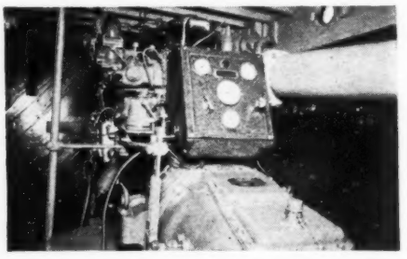
TO SPEED THE ANNEALING of iron alloys, these furnaces built by Continental Industrial Engineers, Inc., are designed for rapid handling of the work. Metal to be heat treated glides smoothly into the furnace on easy-turning rollers. As shown in cross-section, each roller turns on an anti-friction bearing unit assembled from Bantam Needle Rollers. A hardened sleeve, also furnished by Bantam, forms the outer raceway.



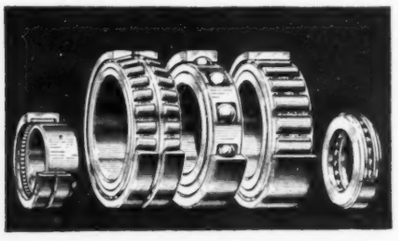
IN MACHINE TOOLS, the Quill Bearing's small size, high capacity, low friction coefficient, and efficient lubrication make it possible to combine long life, low power consumption, and compact product design. A typical instance is the use of Quill Bearings on the front carriage assembly of Semi-Automatic Shell Lathes built by Morey Machinery Co., Inc. For further details on this unusual anti-friction bearing unit, write for Bulletin P-104.



DESIGN OF SPECIAL BEARINGS is an important aspect of Bantam's service in meeting unusual requirements. These triple-race radial ball bearings were designed to eliminate starting friction in dynamometers, where this variable factor would seriously affect the accuracy of the test results. Very close dimensional tolerances were maintained in these bearings as an added assurance of accurate results.



IN MARINE APPLICATIONS TOO, Bantam Bearings play their part in improving product performance. Twin Disc Clutch Company uses Bantam Bearings for the throwout bearing on its widely used Marine Reverse and Reduction Gears, one of which is shown here on a 215-HP engine.



WHEN LARGE-SIZE BEARINGS ARE NEEDED, Bantam's experience in the design and manufacture of heavy-duty bearings is of special value. Bantam's line includes every major type of anti-friction bearing—in sizes up to the largest ever built. If you have a problem involving exceptionally severe bearing requirements, TURN TO BANTAM.

ARMY E NAVY

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION · SOUTH BEND · INDIANA

SUBSIDIARY OF THE TORRINGTON COMPANY · TORRINGTON, CONN.

MACHINERY and EQUIPMENT

Master Line Filter

E. C. R. Weisgerber, 1932 Milford Street, Houston, Texas, announces The Master Line Filter, designed for

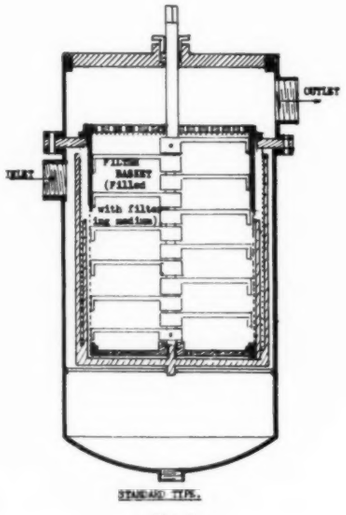


Fig. 1

vapors, gases, air, steam, and liquids. Features of the equipment, as set forth by the company, are: (1) Low back

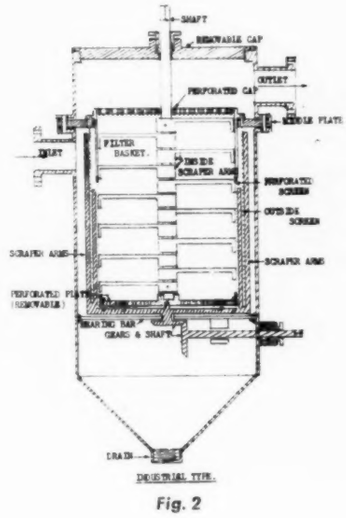


Fig. 2

pressure (back pressure can be easily regulated), (2) easy to service and inspect, (3) operates under either pressure or vacuum, (4) designed for both high and low pressures and temperatures, (5) will not clog, even with the most viscose entrainment, (6) removes the finest floc, suspended matter, etc., (7) need never be taken out of the line for inspection or servicing, (8) any kind of filtering medium can be used, except long-fibred metal or glass wools, (9) compact, durable, and foolproof, (10) can be used as a neutralizer while filtering, and (11) is low in first cost.

Two types of the filter are made, details of which are shown in Figs. 1 and 2.

Voltage Stabilizer

GENERAL Electric Company, Schenectady, New York, has announced a new voltage stabilizer that provides a constant output of 115 volts from circuits varying between 95 and 130 volts.

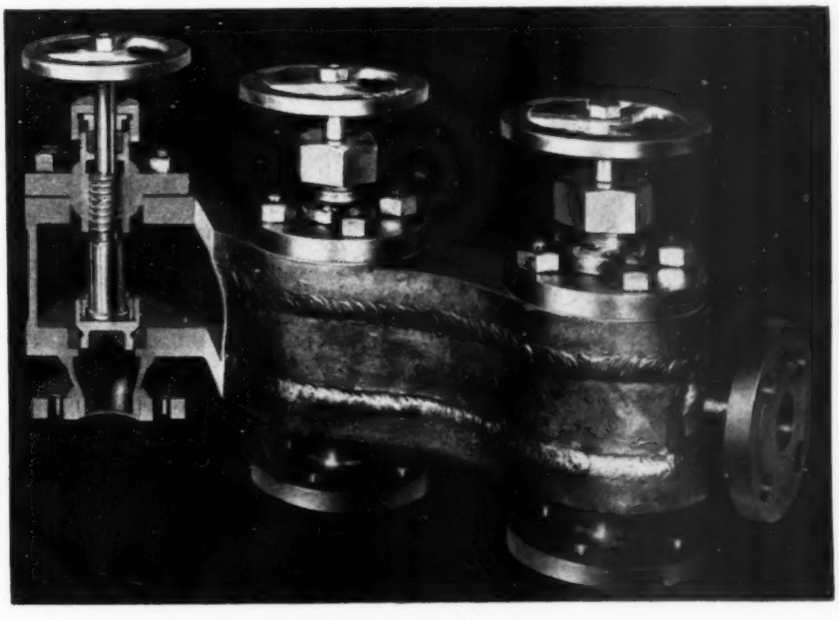
This stabilizer is insensitive to load power factor, it is stated. It is not affected by variations in load from no load to full load or by changes in power factor from unity to 0.8 lagging. It is completely self-protecting, and will operate continuously throughout the range from open circuit to short circuit without damage.

The new stabilizer can be applied wherever close voltage regulation is requisite to good operation. Ratings from 50 kva. to 5000 kva. are available.

Publication GEA-3634 describes the new voltage stabilizer in detail.

Welded Manifold Valves

SIMPLIFICATION of valve-and-piping hook-ups is made possible through the use of welded manifold valves, manufactured by Zallea Brothers and Johnson of Wilmington, Delaware. Any number of valves of any type in any size, of carbon or stainless steel, chrome iron, nickel, monel, or other alloys can be combined in an integrated unit to meet any requirement. Features of welded valves include increased strength with reduced weight, economy of space, ease of installation, and minimum pressure drop, according to the manufacturer.



Welded manifold valves

Synthetic Rubber Mountings Development

ANNOUNCEMENT has been made by The B. F. Goodrich Company, Akron, Ohio, that its line of Vibro-Insulators (rubber mountings) can now be made using its Ameripol synthetic rubber. These mountings, which are used for the isolation and insulation of vibration, shock and noise, have been offered for many years using natural rubber bonded to metal.

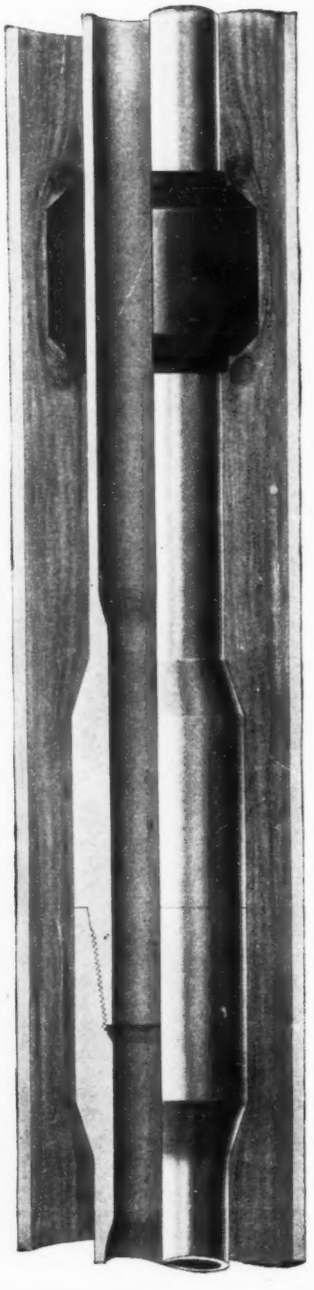
Vibro-Insulators made of Ameripol synthetic rubber are expected to find wide application in many fields of war industry where the action of oils, grease, paint, fatty acids, or heat result in too-rapid deterioration of natural rubber used on mountings.

Most all B. F. Goodrich Vibro-Insulators, whether made of natural rubber or synthetic rubber, are designed to carry the load in shear, because rubber in shear is known to have six times the resiliency of rubber in compression.

Vibro-Insulators have already found many uses in war plants and on war products where vibration, shock or noise were interfering with high-speed production or impairing the functioning of vital equipment, the manufacturer states. They can be cited chiefly for performing these varied functions: (1) Reduce wear and tear on important—and often non-replaceable—machinery; (2) aid in the manufacture and operation of precision instruments and equipment; (3) produce products of necessary higher quality; (4) eliminate noise and vibration that is distracting to production and office personnel; (5) prevent transmission of sound or vibration from one building or one piece of apparatus to another; (6) increase the efficiency of machine operators, and (7) prevent eventual structural weakening or destruction of buildings.

Adding Lips has increased the life of Protectors

Patterson-Ballagh Protectors exclusively embody streamlined lips. These lips add approximately 15% more gripping area. The lips prevent chemical muds from settling around the pipe at the end of the Protector. The streamlining effect reduces mud swirl on the pipe. Patterson-Ballagh Protectors give vital protection to pipe. The life of pipe is vastly increased. The Protectors can be removed from pipe finally worn out and re-used on other pipe.



See Composite Catalog

PATTERSON-BALLAGH CORPORATION

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PATTERSON - BALLAGH DRILL PIPE & CASING PROTECTORS

Plastic Portable Electric Drill

FIRST public announcement of a new Thor plastic ¼-in. portable electric drill has been made by Independent Pneumatic Tool Company, Chicago, Illinois, after nearly a year in which large quantities of the drill have been produced under Army contract.

The grip handle, field case, and gear case of the drill are constructed of a new, tough, light-weight "Thorite" plastic developed exclusively for Thor. Developed last May in Thor laboratories, the plastic-encased drill underwent vigorous tests and is now in use by the Army all over the world, it is stated.

With military requirements on exclusive production of the Thor plastic drill since its development now completed, the tool is for the first time made available to all war industries.

The plastic, streamlined housings have been supplied the Army in an olive drab color, but will be in maroon "Thorite" for general use.

Operating Analysis Chart On Hydraulic Packings

A NEW operating Analysis Chart for the scientific specification and accurate shop record of hydraulic and pneumatic "U" packings has been issued by Wayne Davies and Company, 325 West Huron Street, Chicago, Illinois. The chart, with complete conservation data, will be sent to packing users on request. A binder file can be set up in engineering and maintenance departments to control and record hydraulic packing service.

The bulletin with the chart goes into detail on the hydraulic service improvements developed by Wayne Davies with data and information enabling maintenance engineers to determine exact requirements and dimensions for every condition, for easy record on the accompanying form.

New Chief Metallurgist For Tube Turns

FRED C. SMITH

Tube-Turns, Inc., Louisville, Kentucky, announces the appointment of Fred C. Smith as chief metallurgist.

From 1936 to the date of his present affiliation with Tube Turns, Smith was employed by Carnegie-Illinois Steel Company at Chicago, in the capacity of field metallurgist. Prior to that he was plant metallurgist for the International Harvester Company at Fort Wayne and Chicago plants.

Smith is well known in the metallurgical fraternity. In May, 1942, he was elected vice-president of the American Society for Metals, which office he resigned when he went with Tube Turns. He is also a member of the American Society of Automotive Engineers and other technical organizations.

Pacific Coast Meeting A.P.I.

The annual Spring Meeting of the American Petroleum Institute, Division of Production, Pacific Coast District, will be held March 23, in the Los Angeles Biltmore Bowl.

It will be a dinner meeting, beginning at 6:00 p. m. Title of the program will be "California Petroleum Production for War." Several speakers, headed by E. E. Pyles, petroleum coördinator for the California Conservation Committee, will address the meeting.

Guest speaker will be Herbert R. Gallagher, recently appointed director-in-charge of the District 5 Office (Pacific Coast) of the Petroleum Administration for War. Gallagher, one of the nation's foremost oil men, is a former executive vice-president of Shell Oil Company, Inc., and a former president of Consolidated Oil Corporation. E. K. Parks, chairman of the Pacific Coast District, Division of Production, will preside.

J. W. Horner Joins Guiberson

John W. Horner, experimental research engineer, has joined the development staff of the Guiberson Diesel Engine Company, Dallas, Texas, it is announced by W. E. Lind, director of research for the company, which is expanding its development of radial, air-cooled Diesel engines for aircraft and other uses.

Horner, who is engaged in stroboscopic studies of valve gear, combustion phenomena, and other phases of activity in the Guiberson single-cylinder laboratory, was formerly with the Lawrance Engineering and Research Corporation, of Linden, New Jersey, where he had been engaged in research, and the Chrysler Corporation.

To Hold Joint Meeting

The 28th annual meeting of the American Association of Petroleum Geologists, the 17th annual meeting of the Society of Economic Paleontologists and Mineralogists, and the 13th annual meeting of the Society of Exploration Geophysicists, will be held on April 7, 8, and 9, 1943, at the Hotel Texas, Fort Worth, Texas, at the invitation of the Fort Worth Geological Society.

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FROM WASHINGTON

Asks for 4500 Wildcat Wells

The drilling during 1943 of a minimum of 4500 wildcat wells—50 percent more than were ever drilled before in a single year—has been called for by Petroleum Administrator for War Harold L. Ickes.

Explaining the need for increased wildcatting, Administrator Ickes said:

"Since the year 1938, the volume of new crude oil reserves discovered in any one year has not equalled the volume of crude oil consumed.

"This nation was fortunate in having a substantial backlog of crude oil reserves at the outset of this war. In recent years, however, the paucity of new discoveries of a very large size, coupled with the increasing essential demands for petroleum, is resulting in a continued draft on the Nation's accumulated crude oil reserves at a time when the outlook is for even greater essential petroleum requirements.

"Discoveries of petroleum during 1942 did not exceed 421,000,000 bbl. on the basis of the traditional conservative methods of estimating proven crude oil reserves. On even the most liberal basis of estimation, discoveries did not exceed 801,000,000 bbl. Even this liberal estimate is only 57 percent of the volume of crude oil actually consumed in 1942."

Deputy Administrator Ralph K. Davies, in discussing the necessity for the petroleum industry to undertake efforts at once to expand its search for new petroleum reserves, stated:

"This expanded effort must get under way immediately if the increasing essential requirements for petroleum products are to be met. Each company should review its holdings of prospective oil leases, select those areas having the greatest probabilities of producing oil, and test them as quickly as possible.

"The number of structures that may be found by geophysical methods is diminishing. Therefore, more fields of the non-structural type, which cannot be so readily located by geophysical methods, must be found to maintain the discovery rate. Fields of the non-structural type usually must be found by extensive wildcatting and on the average, more wildcat wells must be drilled to find each such field.

"Greater care must now be exercised and all available geological information must be most carefully studied as a basis for locating wells drilled in search for non-structural type fields.

"Because of the scarcity of critical materials, such as steel, it is imperative that only such locations as have definite merit should be drilled.

"While we are asking for at least 4500 wildcat wells to be drilled during 1943 even more may be desirable. So far as the Petroleum Administration for War is concerned, first preference shall be given to exploratory activities in distributing the materials available to the industry in 1943."

Ban Gas Well Drilling in Texas Panhandle

The use of material for the drilling of new natural gas wells in the Texas Panhandle field was banned February 24 by Petroleum Administrative Order No. 9 issued by the Office of Petroleum Administrator for War Harold L. Ickes.

Effective immediately, the order prohibits the use of any materials to drill, complete, or provide additions to any well in any discovered or undiscovered natural gas field in Carson, Collingsworth, Gray, Hansfield, Hartley, Hutchinson, Moore, Potter, Sherman, or Wheeler counties, Texas.

PAW may issue exceptions to the present ban on the use of materials in the field. Applications to use material to drill, complete, or provide additions to any well must be made by filing a letter in quadruplicate or by sending a telegram to the Director of the Natural Gas and Natural Gasoline Division, Petroleum Administration for War, Interior Building, Washington, D. C., Ref. PAO No. 9.

Drilling Limited in Barnhart Field

The issuance of Petroleum Administrative Order No. 8, which limits the drilling of oil wells to 1 well to each 160 acres in the Barnhart field, Reagan County, Texas, has been announced by Deputy Petroleum Administrator Ralph K. Davies.

The order supersedes, insofar as the Barnhart field is concerned, the general provisions of WPB Conservation Order M-68, which authorizes 40-acre drilling. The productive horizon in this field is found at a depth of approximately 9200 ft. For the most part, operators on their own account have limited drilling to 1 well to each 160 acres or quarter section.

Petroleum Considered War Industry

Paul V. McNutt, chairman of the War Manpower Commission, and Petroleum Administrator for War Harold L. Ickes have issued the following joint statement:

"Reports are being received in Washington from a few places to the effect that oil company employees misunderstood the War Manpower Commission's recent statement about non-deferrable occupations.

"The reports are that oil, natural gas and gasoline company employees engaged in vital and essential jobs in that industry failed to report for work and instead were seeking employment in munitions plants or some other kind of work which they thought was listed as more essential by the War Manpower Commission.

"Petroleum is regarded as one of the most essential of war industries and has been so designated previously by the War Manpower Commission. Bulletins issued by the WMC to local United States Employment Service Offices, and Selective Service Occupational Bulletins Nos. 15 and 21, issued in August and September, 1942, for the guidance of local draft boards and of employers, list 179 specific classes of jobs in the petroleum and natural gas industry and its transportation service which are directly classed as essential activities.

"Oil and natural gas are vital to this war and it does not help to win the war for men who have long been trained and skilled in this industry to leave their present jobs. We wish to emphasize that while planes, tanks, and ships fight the battles, they cannot fight without oil to fuel them. The production, refining, transportation, and distribution of oil and gas are all necessary.

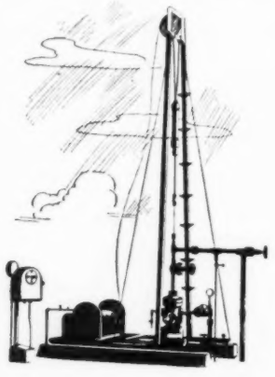
"The same principle applies to other essential industries and to the countless services of civilian supply. Any man who reads the limited list of activities covered by the recent WMC Order will see that it is merely directed at things which either (a) can be done without for the duration of the war, or (b) can be performed by women, older or handicapped workers, or by unskilled workers.

"An Order which was intended to apply to such things as ornamental glass, costume jewelry, or greeting cards does not carry any implication for such vital industries as oil, mining, food processing and other essential industries which wartime America must keep fully manned."

NIXON

Surface Control

GAS-LIFT



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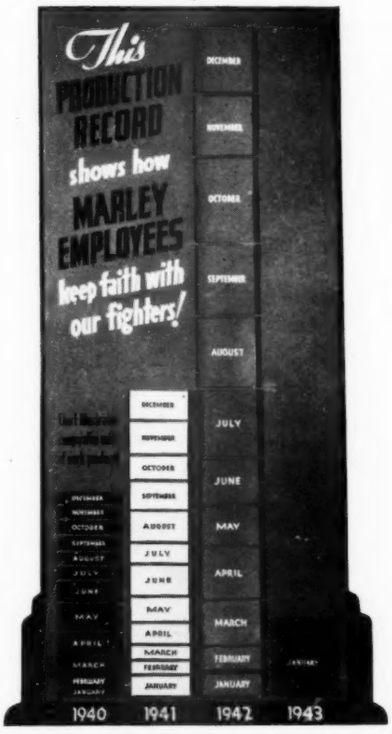
TEXAS—Gladewater, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi.

LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport.

"Output Chart"

The accompanying "Output Chart" is displayed in the lobby of The Marley Company's Kansas City plant. Month by month it keeps Marley workers informed of the results of their efforts, which are devoted 100 percent to production for American and Allied war



plants—and for Army and Navy bases.

For months before Pearl Harbor, Marley's output was 85 percent "defense"—and since then has been exclusively war production.

Marley's production at the beginning of 1943 is triple the same figure for 1942, which was double that for 1941. That the patriotism of the individual workers is the major factor behind this increased output is proved by the fact that it has been accomplished with only slight increase in equipment and personnel, the company's management states.

General Groves Presents Badger Army-Navy "E"

Brigadier General Leslie D. Groves, deputy chief of Construction Division, Office, Chief of Engineers, Washington, D. C., presented the Army-Navy Award for Excellence in war construction to the men and women of E. B. Badger and Sons Company at the West Virginia Ordnance Works, Point Pleasant, West Virginia, on March 4.

E. B. Badger, president of the century-old Boston engineering firm that bears his name, replied to General Groves following the presentation of the Army-Navy "E" pennant. Individual "E" lapel pins were given to approximately 1500 workers.

Lieutenant Commander O. S. Montesi, U.S.N.R., supervisor of shipbuilding, Marietta Manufacturing Company, Point Pleasant, awarded the pins. They were accepted on behalf of the workers by an employees committee of which H. F. Moore of Huntington, West Virginia, was chairman. Other members of the committee were D. L. Adkins, Huntington; R. W. Galloway, Middleport, Ohio; P. L. Jordan, Huntington; J. M. Lawson, Gallipolis, Ohio; Mrs. Sylvia Meeker, Point Pleasant; James W. Noble, Middleport, and Helen F. Richards, Pomeroy, Ohio.

Among the guests of honor were Mayors Paul O. Fiedler, Huntington; Boone Dawson, Charleston; B. W. Krodel, Point Pleasant; William Janes, Gallipolis; Malcolm D. Hartley, Pomeroy, and C. O. Fisher, Middleport. Charles E. Hodges, managing director of the Chamber of Commerce of Charleston, was master of ceremonies.

A.P.I. Meeting in Tulsa

The Spring Meeting of the Mid-Continent Section, Production Division, of the American Petroleum Institute, will be held in Tulsa, Oklahoma, May 20 and 21, it has been announced.

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Under the tremendous weights, strains and impacts of drilling and producing operations, heavy duty equipment will stand the gaff only if the bearings function flawlessly. AMERICAN SUPER HEAVY DUTY Roller Bearings are built with the vital extra capacity to take it. They will keep your heaviest rig equipment producing with maximum efficiency. Consult our engineers for full technical facts.
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Ohio Injector Company Wins New Honors

The Ohio Injector Company of Wadsworth, recipient of the Army-Navy "E" award and pennant for high achievement in the production of war goods, has won additional honors, according to announcement by the Navy Board of Production Awards at Washington.

The Ohio Injector Company's Army-Navy "E" award, which was made last summer, not only has been renewed for continued high achievement in the production of war goods, but now has had added to it the white star.

In announcing the new honors, Admiral C. C. Bloch, USN, retired, chairman of the Navy Board for Production Awards, in a letter to Wayne Young, president of The Ohio Injector Company, stated:

"I congratulate each and every one of the employees of The Ohio Injector Company upon their continued splendid achievement in outstanding production. This award is difficult to win in the first instance and the requirements for renewal are equally exacting. By winning this additional honor you all have demonstrated a solid determination to supply our fighting forces with the materials they must have to bring this war to a successful conclusion."

Opens Consulting Engineering Office

G. G. HARRINGTON

George G. Harrington, one of the most widely known engineers in the oil-equipment field, on March 1, 1943, opened an office in the Esperson Building, Houston, Texas, as a consulting engineer.

For the last 11 years Harrington has been chief engineer of the Reed Roller Bit Company.

Harrington graduated in engineering from the University of Texas with the degree of bachelor of science in mechanical engineering and entered the employ of the Reed company after having served in the Engineering Department of the Houston Gas and Fuel Company and Houston Lighting and Power Company.

Wickwire Spencer Appoints Shattuck Wire Sales Manager

Wickwire Spencer Steel Company, 500 Fifth Avenue, New York City, has announced the appointment of Wilfred C. Shattuck as wire sales manager. Shattuck will have his headquarters in the company's New York offices.

Shattuck was graduated in 1924 from Brown University with the degree of Ph. B. After a year's law study at Columbia University, he joined the sales staff of Wickwire Spencer, with whom he remained in various sales capacities until 1940.

He returns to Wickwire after two years with John A. Roebling's Sons Company, first in their New York office and later as manager of sales, round wire, flat wire and specialties division, Trenton, New Jersey.

Save Critical Materials—Lessen Drilling Grief—With Acme's Mud Collar

Makers of the world famous "Drilmor" Line of Drilling and Fishing Tools for Cable Drillers - the Highest Standard of Quality Since 1900

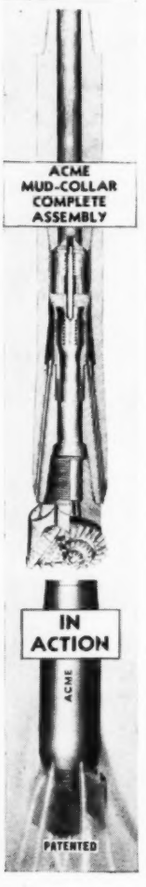
There are few Mud Collars in stock. You know the difficulties of obtaining *critical materials*. And, too, Acme is now in war production. So, don't delay placing your Mud Collar order—as deliveries from *new stock* cannot be promised for "the duration."

Here's what Acme's Mud Collar can do for you—as proven by satisfied users—in any formation:

It lessens drill pipe torque; assures faster, easier cutting, longer runs, fewer "green bits" and makes better hole. . . . Its 6 high-velocity fluid streams keep cutters clean, bit bearings "lubricated" and free of cuttings—while constantly flushing bottom. . . . In sticky formation, it also prevents mud rings and "balled up" bits.

Decrease material purchases by increasing the life of bits and drill pipe. Learn how—with this "wonder tool." Write TODAY for full information. *And don't delay your order. (Also ask for Catalog No. 12. It gives valuable information on correct use and care of Acme cable tools.)*

With Acme's facilities largely devoted to war production, Defense comes FIRST! But we'll serve YOU as best and long as we can—and in friendly fashion.



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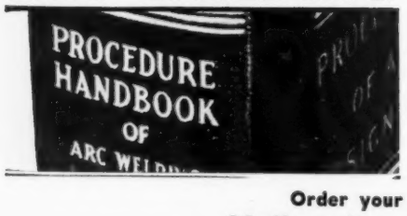
New Book on ARC WELDING



New Edition "Procedure Handbook of Arc Welding." Bigger than ever. Wider in scope. Latest information on all phases of arc welding—the ace process of war production and key to progress and increased earning power in post-war era.

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National Supply Wins Third Production Award

The National Supply Company was the recipient of its third War Production Award recently with the presentation of the Army-Navy "E" to the employees of its Toledo, Ohio, Plant. The two previous awards consisted of the Army-Navy "E" at the Ambridge, Pennsylvania, Plant and the U. S. Maritime Commission Victory Fleet Flag and Maritime M Pennant to the Superior Engine Division at Springfield, Ohio.

A. E. Walker receives Army-Navy "E" Pennant from Rear Admiral William C. Watts

Presentation of the Toledo Plant Award Flag was made to President A. E. Walker by Rear Admiral William C. Watts, U.S.N., retired. "We regard it as a token of partnership with those brave sailors and soldiers fighting in the far corners of the world to maintain the rights of free men," said Walker in his acceptance speech.

Col. Ernest O. Rudelius presented "E" pins to the four oldest employees of the plant whose tenure of continuous service ranged from 44 to 51 years. Pins were accepted in behalf of the employees by J. S. Biscay, president of The National Supply Unit, U.A.W.-C.I.O.

Governor Saltonstall, Governor of Massachusetts, gave the principal address and paid tribute to the workers and management in declaring, "All of us are working together on the home front as well as on the battle front."

Interstate Oil Compact Meeting April 2-3

Plans to produce motion pictures to show the benefits of modern conservation practices in the production of oil and gas will be made by the Interstate Oil Compact Commission at its spring quarterly meeting in the Allis Hotel, Wichita, Kansas, April 2 and 3, Chas. L. Orr, commission secretary, has announced.

To aid the commission in formulating these plans the U. S. Bureau of Mines will exhibit at the Friday afternoon session its sound motion picture "Evolution of the Oil Industry." Other sound pictures in technicolor will be shown illustrating the vital part modern engineering science plays in the efficient and economic production of oil.

Petroleum engineers and technicians from state regulatory bodies and from the petroleum industry will collaborate with the commission in the preparation of definite plans to carry out this educational program.

Other features of the meeting will be the national stripper well survey brought up to date with 1942 data, and a study of the nation's petroleum reserves.

A brilliant blitz may win a battle, but it takes staying power to win a war. Case Oilfield Engines are helping to win this war because they have that kind of power. We call it endurance.

Well-balanced endurance naturally brings dependability. Together they enable Case Oilfield Engines to run non-stop for amazingly long periods, to maintain their fuel and oil economy, to work with little attendance, to attain long life with low upkeep. Your Case distributor can give you the evidence, either in engineering detail or by records from jobs similar to yours.

Case Oilfield Engines are built in two sizes, rated at 40 and 60 horsepower on gasoline. They may be fitted for gas and for other liquid fuels. They are available for operations deemed essential to the war effort. Your Case distributor will gladly give you full information. J. I. Case Co., Racine, Wis.

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ALLIED SUPPLY COMPANY
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Since 1842 IN PEACE AND WAR

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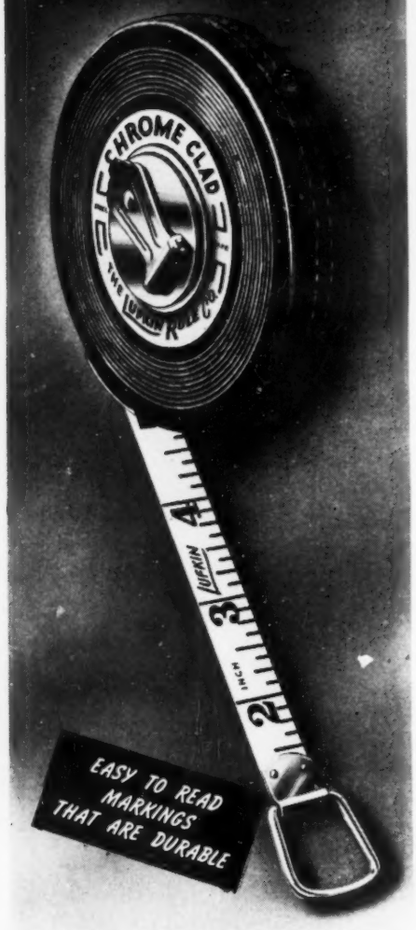
"ANCHOR" CHROME CLAD STEEL TAPE — THE OILMAN'S CHOICE



ONE HALF INCH LINE

A sturdy, finely-built tape that every busy oilman will want to carry. Jet black markings on the satin chrome finish are easy to read—even in poor light. Surface won't rust, crack, chip or peel. Genuine leather case. Folding flush handle is opened by a push pin. See the "Anchor" at your supply house and write for catalog.

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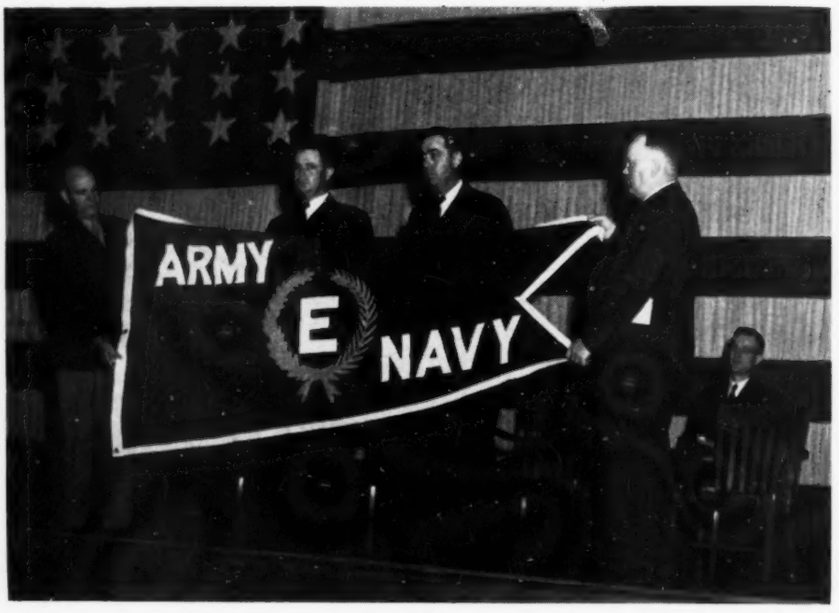
TAPES · RULES · PRECISION TOOLS

Brewster Company Award



This photograph was taken at the official presentation of the Army-Navy "E" Production Award to The Brewster Company, Shreveport, Louisiana. Left to right are: Colonel E. C. Bomar, District Chief, Birmingham Ordnance District; Lt. Commander Kenneth C. Elliott, United States Navy; Herbert A. Harlan, production manager, The Brewster Company; A. Olin Price, vice-president and general manager, The Brewster Company; and Ernest D. Garrett, chief engineer, The Brewster Company.

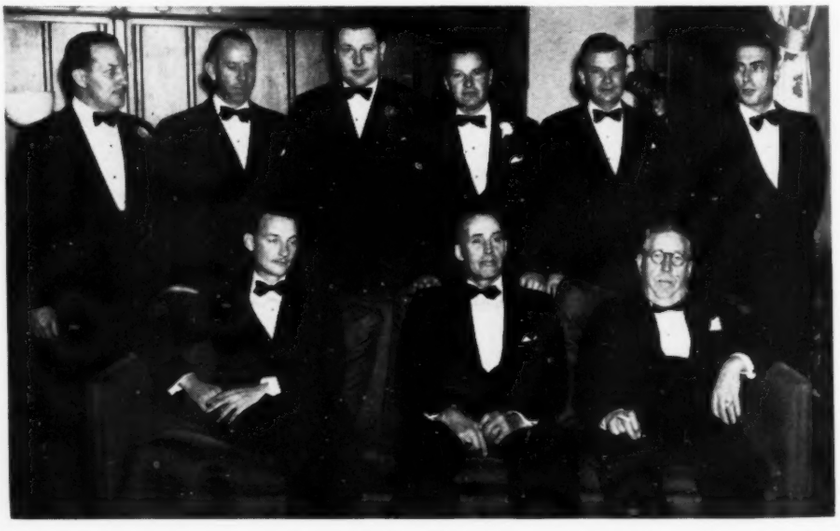
The program was February 4 in the Shreveport Municipal Auditorium.

The Brewster Company is also privileged to fly the Treasury "T" Flag by reason of the fact that the investment of Brewster employees in war bonds averages 11 percent.

Los Angeles Nomads Hold Inaugural Ball

The Fourth Annual Inaugural Ball of the Los Angeles Chapter of Nomads was held at the Elks Club in Los Angeles, February 19. More than 200 Nomads and guests began assembling for cocktails at 7:30 and then gathered in the El Venado Room for a dinner dance at nine. Music was by Art Whiting's orchestra. At eleven o'clock a floor show received the hearty approval of all present.

The Ball was in honor of the outgo-



Officers of Los Angeles Chapter of Nomads for 1943. Sitting: W. F. Bettis (left), Regent; H. R. Pullman, President, and W. R. Martin, Regent. Standing: W. A. Sawdon (left), Secretary; T. Martin, Assistant Secretary; J. V. Robinson, Sergeant-at-Arms; R. E. Smith, Vice-President; E. R. Smith, Treasurer, and R. Henquet, Assistant Treasurer

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Floor Boxes—Wiring Specialties

"Bull Dog" PIPE or CONDUIT HANGERS

Sturdy, efficient, economical and adaptable for wide range of work.

Made of high quality malleable iron, electro plated with cup point, case hardened set screw.

The saddle or pipe support turns freely, permitting pipe to run parallel to beam or at angles, making installation easy and the use of straps unnecessary.

No. 470 may be used to hang sizes ½ in., ¾ in. and 1 inch to steel beams ⅜ in. thick.

No. 471 for pipe sizes 1¼ in. to 1½ in. We also make "Bull Dog" Insulator supports and other wiring specialties.

Jobber inquiries invited. Price list and complete information upon request

FULLMAN MANUFACTURING CO.
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Look for the *Arm and Hammer*

ARMSTRONG BROS.

CHAIN TONGS

You can show lower tool cost if you standardize on ARMSTRONG BROS. CHAIN TONGS, for they have no "weakest link".

Jaws are drop forged from special steel, are hardened, tempered and tested for wearing qualities. Chains are proof-tested to two-thirds catalog strength (3,600 to 40,000 lbs.). Handles, shackles, bolts . . . tested steels, tested designs . . . Proven strength that will not fail, that will always stand up and give long, dependable service.

"The Tool Holder People"
ARMSTRONG BROS. TOOL CO.
331 N. Francisco Ave., Chicago, U.S.A.
New York Warehouse & Sales:
199 Lafayette St., New York

ing and incoming officers and regents of the Los Angeles Chapter. The outgoing officers were: W. F. Bettis, president; E. M. Rees, vice-president; R. J. Eiche, secretary; J. C. Ballagh, assistant secretary; E. R. Smith, treasurer; D. B. Waite, assistant treasurer; R. E. Smith, sergeant-at-arms, and T. Murphy, deputy sergeant-at-arms.

The outgoing Regents were E. B. Fowks and T. Sutter.

The incoming officers are: H. R. Pullman, president; R. E. Smith, vice-president; W. A. Sawdon, secretary; T. Martin, assistant secretary; E. R. Smith, treasurer; R. Henquet, assistant treasurer; J. V. Robinson, sergeant-at-arms, and L. G. Trembley, deputy sergeant-at-arms.

The Regents for 1943 are W. F. Bettis and W. R. Martin.

The arrangements for this most successful affair were made and carried through by the Arrangements Committee consisting of Roland Smith, chairman; W. F. Bettis, J. V. Robinson, H. E. Cassidy, Lew Bronzan, and W. A. Sawdon.

Two of the retiring officers could not be present because they are in the armed forces—Earl Rees who is with the Marines and Tom Murphy with the Air Force.

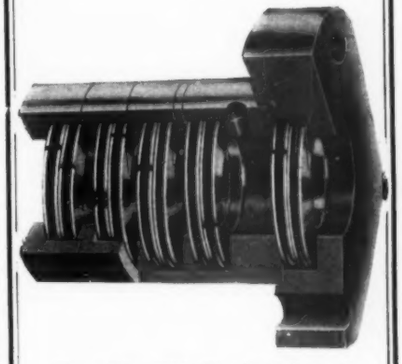
Bert Harris of "Oilwell" Retires

BERTRAM L. HARRIS

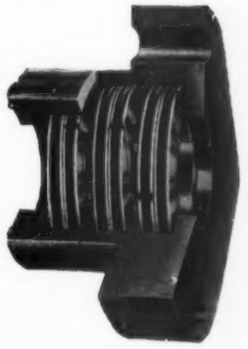
Bertram L. (Bert) Harris, manager of the Bartlesville, Oklahoma, office of Oil Well Supply Company and one of the best known oil-field supply men in Oklahoma, retired March 13, after 41 years' active service with his company. He started with "Oilwell" on March 1, 1902, at the company's Findlay, Ohio, store. Subsequently he managed both the store and the field shop maintained by "Oilwell" at that point. In 1909 he was transferred to Bradford, Pennsylvania, and on December 6, 1915, he moved to Bartlesville, where he has represented "Oilwell" for 27 years.

KEEP 'EM HUMMING!

√ Compressors
√ Engines
√ Pumps



Type No. 270. Designed especially for gas compressors. France Metal "Full-Floating" Packing is outstanding for its long wearing qualities. Eliminates frequent shut-downs.



Type No. 190. Designed for shallow stuffing boxes. Prompt delivery assured.

Specify the packing that L-A-S-T-S — FRANCE "Full-Floating" Metal Packing. *Ask for catalog No. M-3.*

THE FRANCE PACKING COMPANY
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Mid-Continent Representative:
MR. J. M. FULLER, 3725 W. 7th St.
FORT WORTH, TEXAS

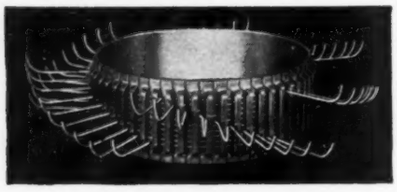
Original
FRANCE
METAL PACKING

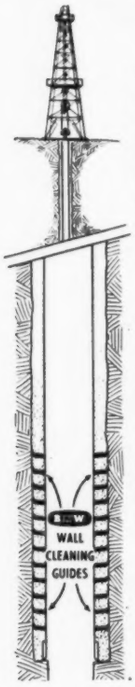
Prevent CRATERING

by using . . . B and W, Inc.

WALL CLEANING GUIDES

on your SURFACE CASING





1 TO PREVENT BLOW-OUTS

Wall Cleaning Guides placed on the bottom joints of surface casing protect against blow-outs around the casing, or cratering from an imperfect cement job.

2 TO PREVENT BACKING OFF

The rotation and jarring of the drill pipe tends to loosen the threads of the bottom joint of surface casing, particularly opposite an imperfect cement job. The unscrewing of this joint may result in an impossible fishing job, or abandonment.

Wall Cleaning Guides placed on the bottom joints will assist in securing a *perfect* cement job, which in turn will securely anchor the casing to the formation.

● *Table of Dimensions*

Casing Size	Hole Diameter	Outside Wire Diam.
8⅝"	12¼"	14½"
9⅝"	12¼"	14½"
10¾"	14¾"	16¾"
13⅜"	17¼"	18½"

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R. Smith New Durametallic Sales Manager

Announcement has been made by C. C. Hall, executive vice-president, Durametallic Corporation, main offices in Kalamazoo, Michigan, of the advancement of Roscoe R. Smith, formerly manager of their Chicago sales office, to the position of sales manager and chief of field engineers.

Smith has been associated with Durametallic since 1928. He has been a successful sales representative in the territories of western Michigan, Indiana, Ohio, and Kentucky for the flexible metallic packings and sealing devices

ROSCOE R. SMITH

manufactured by this concern. "Rosc.", as he is known by his many friends, has more recently built up a large acquaintanceship in the Chicago and Illinois area as well as Wisconsin, Minnesota, and Iowa during his period as manager of the Chicago sales district with offices in the Fairbanks-Morse Building at 600 South Michigan Avenue.

Smith is a firm believer in rendering personal engineering service. He plans to make personal calls with Durametallic field engineers on plants and projects in the territories covered by the Durametallic Corporation.

Maritime "M" to Edward Valve

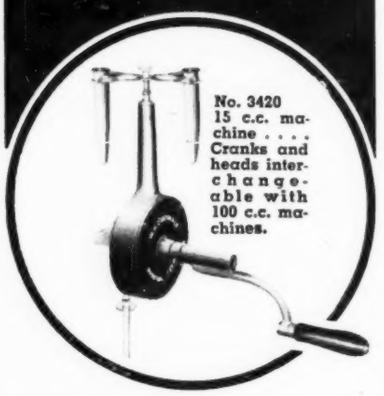
The Maritime "M" pennant and labor merit insignia, highest production honors of the United States Maritime Commission, have been awarded to The Edward Valve and Manufacturing Company, Inc., East Chicago, Indiana, Rear Admiral H. L. Vickery, chairman of the Commission's Board of Awards, has announced.

The Edward company has been building cast- and forged-steel valves for the Maritime Commission ships since the inception of the Commission's "C" type shipbuilding program in 1938.

Presentation ceremonies were held in the plant on March 13.

For QUICK, ACCURATE TESTS

Use CURTIN CENTRIFUGES



No. 3420 15 c.c. machine . . . . Cranks and heads interchangeable with 100 c.c. machines.

Simple in design . . . Ruggedly built . . . Require no special care . . . Great Ratio and throw of crank produce required speed with no strain. Curtain Centrifuges meet all *A.S.T.M. Standard Method D-96-40* and *A.P.I. Code No. 25* requirements. Fully descriptive literature upon request.

W·H·CURTIN & CO. Inc.

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ALL WATER Can Be "Pure"

for use in boilers and tubes when SAND-BANUM is consistently used to both remove and prevent scale and corrosion.

"The Entirely Different Boiler and Engine Treatment"

That is a strong statement. The performance of the product is proof conclusive. It is a pure vegetable compound of tropical resins constant under heat.

SAND-BANUM is entirely active ingredients, with no carrying vehicle. Eliminates need of water analyses, and automatically functions regardless of water or operating conditions.

You can conserve with SAND-BANUM. It brings you a sense of operating security and safety. There is no obligation in immediately writing for details and data.

AMERICAN SAND-BANUM COMPANY, Inc.

9 Rockefeller Plaza, New York City

Richardz Named Manager of Gear Engineering

Folke Richardz, an engineer for 17 years with the Westinghouse Electric and Manufacturing Company, has been appointed manager of engineering in the company's Gearing Department at the Nuttall Works, Pittsburgh, Pennsylvania. He succeeds S. L. Crawshaw, resigned.

Richardz was graduated in 1921 from the Institute of Technology in Katerineholm, Sweden.

He joined Westinghouse in 1926 as a design engineer in the radio and photophone department at East Pittsburgh. In 1931, Richardz was assigned to the Nuttall Works as a design engineer, being appointed section engineer in the Gearing Department a year later.

Southwestern District A.P.I. to Meet

The Southwestern District, American Petroleum Institute, Division of Production, will hold its meeting in the Rice Hotel, Houston, Texas, April 29 and 30, it is announced by R. O. Garrett, chairman.

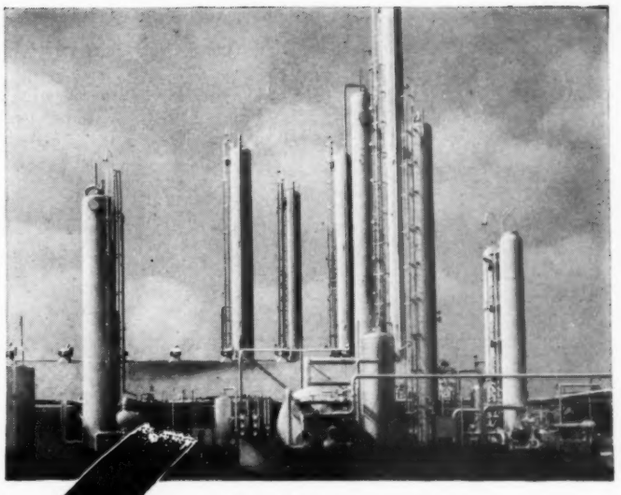
Crane Co. Receives Army-Navy "E"

In one of the largest indoor "E" award ceremonies on record, 15,000 workers and guests took part in the recent presentation at the Chicago Works of Crane Co., manufacturers of valves and fittings. The honor was given Crane in recognition of the volumes of valves produced for the Navy, Army, and for vital war industries.

The impressive ceremony was held between shifts and was broadcast over a nation-wide radio network while all personnel in all Crane's 138 branches throughout the U. S. listened it. The program was opened by V. P. Rumley, vice-president in charge of manufacturing, with Captain L. P.

Left to right: Estelle Maslowski, representative worker, Rear Admiral Clark H. Woodward, J. H. Collier, president of Crane Co., Howard H. Upton, representative worker, and Colonel J. F. Butler

Lovette, U.S.N., as master of ceremonies. Rear Admiral Clark H. Woodward, U.S.N. (retired), Chief of Incentive Division, Navy Department, and designer of the present "E" award, presented the flag to John H. Collier, president of Crane Co. The prized "E" pins were given to six representative workers by Colonel J. F. Butler, U.S.A., Chief of Military Personnel Branch of 6th Service Command. Acceptance on behalf of his fellow workers was made by Howard H. Upton, a special turret lathe operator in the steel valve department. Among the guests were a number of the 3600 Crane workers now in the Armed Forces.



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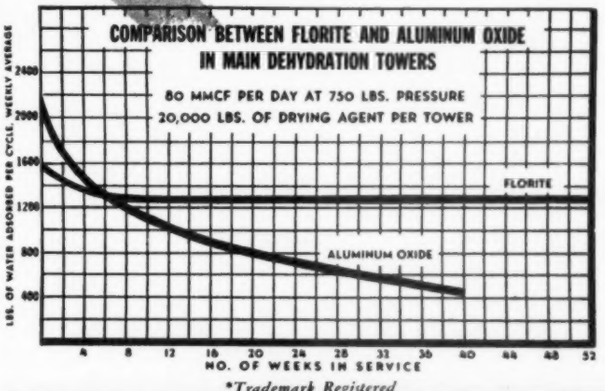
REPRESSURING
the approved Desiccant is

*Florite**

The chart below represents the long-term efficiency of FLORITE* as a drying agent for natural gas. FLORITE* is now the approved desiccant in many such operations, especially those for repressuring. Is equally effective in the treatment of various other gases and liquids. Will selectively adsorb 4 to 20% its weight of water—is regenerated by heating to 350° F. Nationally known chemical manufacturers are among the regular users. Full information on request.

The long-sustained effectiveness of FLORITE in adsorbing relatively large amounts of water is shown. Note that the results were more and more favorable to FLORITE as weeks passed.



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Floridin Company, Inc.
ADSORBENTS
120 LIBERTY AVE. WARREN, PENNA.

ENSIGN'S modern manufacturing facilities and more than 30 years of experience in producing efficient carburetion equipment are now all-out for Victory. Day and night, we are devoting practically our entire resources to help win the war.

But, although unable to provide our usual prompt service due to the war's demands, ENSIGN Carburetion Equipment is still available, and quick delivery of emergency parts is being maintained.

Now, as in the past, ENSIGN Carburetors for Natural Gas, Butane-Propane and Gasoline still lead the field for internal combustion engines of all types and sizes.

ENSIGN
CARBURETOR CO., LTD.
HUNTINGTON PARK • CALIFORNIA

Prepare, NOW, for post-war demands. Our competent engineering staff is at your service.

It's Your Move!

When you have worked at a thing 25 years you are either good or stagnated. We are the oldest and largest exclusive manufacturer of pumping equipment in existence. As compared with the results of other devices, a JENSEN Pumping Unit makes oil from any well relatively cheap and dependable. And we are still growing, still investigating, still improving. It's your move — we can't help any man until he's willing to help himself. ASK FOR BULLETIN NO. 27.

JENSEN
BROTHERS MFG. CO.
Coffeyville, Kansas, U. S. A.
Export Office: 50 CHURCH STREET, NEW YORK CITY

TRADE LITERATURE

What to Write For

Staynew Filter Corporation, 2 Centre Park, Rochester, New York, has a 40-page catalog illustrating the entire Staynew line of filters. The catalog is offered free and the company asks that the party making the request mention any special problems he may be having.

Durametallic Corporation, Kalamazoo, Michigan, has available Dura Seal Bulletin No. 174C, which discusses the application of its packing to oil refineries, synthetic rubber plants, chemical plants, and other industries.

"Piping Pointers" Bulletin No. 6 has been issued by Crane Co., 836 South Michigan Avenue, Chicago, Illinois. This publication gives valuable suggestions on alternate materials to use when there is a shortage of the materials desired, and gives handy hints for making emergency installations.

Cycoil Bulletin No. 130D gives complete information on the operation of Cycoil and other types of air filters manufactured by American Air Filter Company, Inc., 384 Central Avenue, Louisville, Kentucky.

Waukesha oil-field engines are described in Bulletin 1079, issued by the Waukesha Motor Company, Waukesha, Wisconsin. Copies are available free.

Information on motorizing equipment in hazardous places is given in Bulletin No. GEA-3647, by General Electric Company, Schenectady, New York.

The Aldrich Pump Company, Allentown, Pennsylvania, is offering free literature on pumping problems. The company manufactures pumps for pipe-line, refinery, and oil-field service.

The France Packing Company, Tacony, Philadelphia, Pennsylvania, has available Catalog No. M-3, giving information on the packing of compressors, engines, and pumps.

Jensen Pumping Units are fully pictured and described in Bulletin No. 27 issued by Jensen Brothers Manufacturing Company, Coffeyville, Kansas.

Wheatley Brothers Pump and Valve Manufacturers, Tulsa, Oklahoma, has available four bulletins. For information on equalizers write for Bulletin E31; on pumps, Bulletin E32; on check valves, Bulletin E33, and on gate valves, Bulletin E34.

Name of Advertising Agency Changed

The firm name of Wallace Davis and Company, Houston, Texas, has been changed to Davis-Dyke and Company, Advertising, effective March 1.

Move New York Office

Mixing Equipment Company, Inc., has moved its New York office from 377 Broadway to 136 Liberty Street. Glenn J. Moorhead, formerly Pittsburgh representative, has assumed the position of eastern divisional sales manager. C. F. Donovan continues as manager.

Book Reviews

The Chemical Technology of Petroleum by William A. Gruse and Donald R. Stevens, Mellon Institute of Industrial Research. Published by McGraw-Hill Book Company, Inc., New York, New York, 733 pp. Price: $7.50.

This book is the second edition of "Petroleum and Its Products" published in 1928 by one of the authors. As the technology of petroleum has undergone almost revolutionary developments, it was found much easier to start at the beginning in preparing the second edition. A renaissance in aliphatic chemistry has occurred and a new technology of petroleum has arisen, outstripping the science that underlies it.

The present work is intended, like its predecessor, to help investigators and advanced students to find their ways into the science and technology of this most recent and intriguing of the great organic raw materials. The effort to render the work as complete as practicable has resulted in doubling the size of the original volume; a new title has therefore seemed appropriate.

●

Important Facts About Texas Oil. Booklet prepared by The Texas Mid-Continent Oil and Gas Association, Dallas, Texas.

For the first time it may be said that all Texas is in the oil business. Every county in Texas is now under development for oil and gas production and State and local taxes paid by this one industry in 1942 reached a new peak of more than 94 million dollars out of 236 million dollars levied in all business and property taxes, according to a survey of the association.

The new booklet shows that 168 counties of the State are now producing oil and gas and that leasing and exploration for new oil and gas fields are being carried on in the remaining 86 counties. An analysis of State tax revenue, contained in the booklet shows that the Texas petroleum industry now pays more than 52 percent of all business and property taxes.

Minneapolis-Honeywell Branch Executive Dies

Fred W. Balderson, office manager of the Minneapolis-Honeywell Regulator Company's branch at Philadelphia, died on February 20 after an illness of three months. Balderson, who was 32 years old and had been with the company for 12 years, is survived by his widow and infant daughter.

Ben F. Kelley Forms New Company

Ben F. Kelley, formerly with Shaffer Specialty Company, has organized the Ben F. Kelley Company, 212 Beacon Building, Tulsa, Oklahoma. He announces he is manufacturing and marketing the Kelco Safety Spinning Line Cathead, formerly known as the Shaffer Safety Spinning Line Cathead, as well as other patented items.

Kelley went to Oklahoma in 1909, doing field work for the Gypsy Oil Company. In 1912 he went with Continental Supply Company at Tulsa and remained with that firm until 1920, at which time he became western representative for the Titusville Iron Works Company. In 1936 he purchased stock in the Shaffer Specialty Company and was made vice-president and sales manager, remaining with that company until February 1, 1943.

Security Engineering Moves Gulf Coast Offices

Security Engineering Company, Inc., announces that its Gulf Coast Offices are now in Suite 1053 of the Mellie Esperson Building, Houston, Texas.

MAKES YOU CAPTAIN OF YOUR WELL
...IN FULL CONTROL AT ALL TIMES!
The GUIBERSON CONTROL HEAD PACKER places the operator in control of the very elements that threaten the life of his well and endanger its production. By confining the flow to the tubing, it conserves gas pressure, extends well life and safeguards the gravity of the crude. A new factor of control, too, in bringing in wells, raising fluid level, sealing off back-water and acidizing. Ask for details—or consult your Composite Catalog.
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Now supplying critical materials to the Army, Navy, Marines and Army Air Forces
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LIFE EXTENSION SERVICE FOR OIL WELLS

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FUTURE PREFABRICATION IN OUR SOUTHLAND

We have built more than 10,000 homes in 25 years; we were in the vanguard in giving validity to the prefabrication principle; our credo—*time* is what we make—*speed* is what we deliver—*quality* is what we provide.

Our plant is now in full production, serving industry in its war requirements; after VICTORY we'll be on the alert to serve again civilian needs.

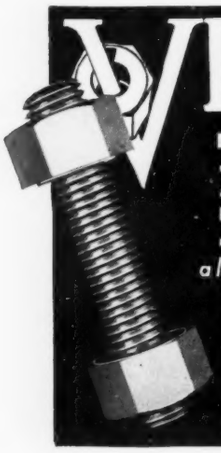
Buy a home in the peace to follow —with the Bonds you buy today.

WORKING NOW FOR **U. S.** BUT LATER FOR YOU

HOUSTON *Ready-Cut* HOUSE CO.

25 years Prefabricating Houses

POLK AVENUE HOUSTON, TEXAS



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BOLTS, STUDS, NUTS

of high strength, heat-treated alloy steels, corrosion and heat resistant alloys, non-ferrous metals and carbon steels for refineries, natural gasoline plants and manufacturers of refinery and oil field equipment.

also

VICTOR Heat-Treated alloy steel STUDS for flanged fittings and valves.

Write for complete Catalog!

VICTOR PRODUCTS CORP.
2643 Belmont Ave. Chicago, Ill.

Everybody... Every Payday...

10% IN WAR BONDS

Along with increased war production goals go increased costs ... extra billions which must be raised, and raised fast, to win this war. That means we must raise our sights all along the line, with every firm offering every American with a regular income the chance to buy more War Bonds. YOUR help is asked in encouraging employees to put at least 10 percent of their pay into War Bonds every pay day, through the Payroll Savings Plan.

U. S. WAR SAVINGS BONDS

MEETINGS

California Natural Gasoline Association, Monthly Meeting—April 1, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

Interstate Oil Compact Commission, Quarterly Meeting—April 2 and 3, Wichita, Kansas.

American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, Society of Exploration Geophysics, Joint Annual Meeting—April 7, 8, and 9, Hotel Texas, Fort Worth, Texas.

American Petroleum Institute, Division of Production, Eastern District—April 8 and 9, William Penn Hotel, Pittsburgh, Pennsylvania.

American Chemical Society, Annual Meeting—April 12, 13, 14, 15, and 16, Detroit, Michigan.

Natural Gasoline Association of America, Annual Meeting—April 14, 15, and 16, Dallas, Texas.

American Petroleum Institute, Division of Production, Southwestern District—April 29 and 30, Rice Hotel, Houston, Texas.

Petroleum Industry Electrical Association, Annual Meeting—May 5 and 6, Houston, Texas.

American Petroleum Institute, Mid-Continent Section, Division of Production—May 20 and 21, Tulsa, Oklahoma.

S. X. Willard to Staff of Conservation Equipment Corp.

The Conservation Equipment Corporation, 624 South Michigan Avenue, Chicago, Illinois, announces the appointment of S. X. Willard as vice-president.

Identified with the oil industry since 1914, Willard has in the last seven years devoted himself exclusively to the conservation of gasoline and other volatile liquids through the reduction of evaporation losses and the elimination of the hazards normally associated with excessive pressure and vacuum in storage tanks.

In 1936, as executive of a manufacturing company, Willard was instrumental in introducing a new type of vent valve in which mechanical weights, pallets, and stems were replaced by a liquid seal that rose and fell according to atmospheric pressure.

More recently, Willard served as conservation engineer for the Graver Tank and Manufacturing Company, East Chicago.

Bristol Company Promotions

L. G. Bean has been promoted to the post of vice-president in charge of engineering and sales from the position of vice-president and general sales manager, by The Bristol Company,

L. G. BEAN

H. E. BEANE

Waterbury, Connecticut, according to an announcement by Howard H. Bristol, president.

Harry E. Beane, who has been field sales manager, becomes general sales manager.

E. L. Stilson has been named assistant sales manager. He has been associated with the Field Engineering Department.

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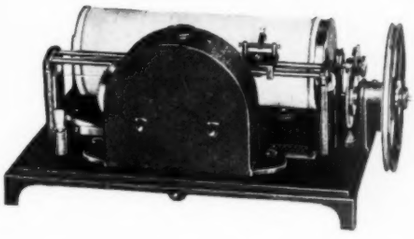

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Automatic, graphic records of tank levels from which volume of flow per unit of time may be determined.

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Automatic records reduce operating costs and conserve manpower!

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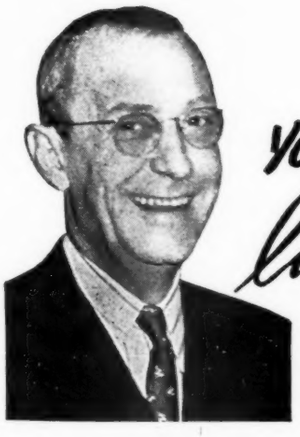

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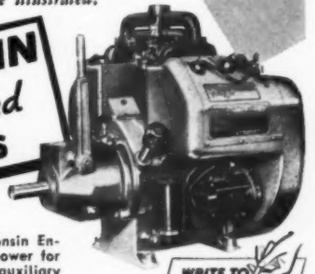

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